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THE MAGPIE ROBIN (*COPSYCHUS SAULARIS*).

Original Articles

LATE COLONEL JOHN FARMER, C.I.E., F.R.C.V.S.

BY the death of Colonel Farmer in Dublin on August 29th, 1920, the Veterinary Profession in general, and the Indian Civil Veterinary Department in particular, have suffered an almost irreparable loss.

Colonel J. Farmer was the eldest son of the late Major Farmer, 4th Hussars.

He obtained his diploma at the new Veterinary College, Edinburgh, in 1892. He had some experience of practice in Dublin before joining the A. V. D. at Aldershot in June 1893.

He arrived in India in the same year and joined at Kirkee on the 12th October.

He was in charge of the Poona Veterinary School for three months in 1894. Next he served in military hospitals at Kamptee, Mhow and Neemuch, and at Bombay on Remount duty till he became Superintendent, Civil Veterinary Department, Central Provinces, at Nagpur in March 1898.

After a short period in the Central Provinces, at Ajmer as Principal of the Veterinary College, and as Superintendent, Civil Veterinary Department, Rajputana, he was posted to the Government Cattle Farm, Hissar, as Assistant to Major Gunn in November 1899.

He became Superintendent of the farm on 2nd March, 1902, and remained there till 12th June, 1912, when he was transferred to Lahore as Chief Superintendent, Civil Veterinary Department, Punjab, which appointment he held at the time of his death. In Colonel Farmer, the department and the Government of the Punjab have lost an enthusiast

Most of his service was spent in the Punjab, and whatever he undertook he worked at with enthusiasm. The writer did not make his acquaintance till 1911, when he was already one of the senior members of the department. He was even then more enthusiastic over all things connected with his work and profession than the most enthusiastic student at college.

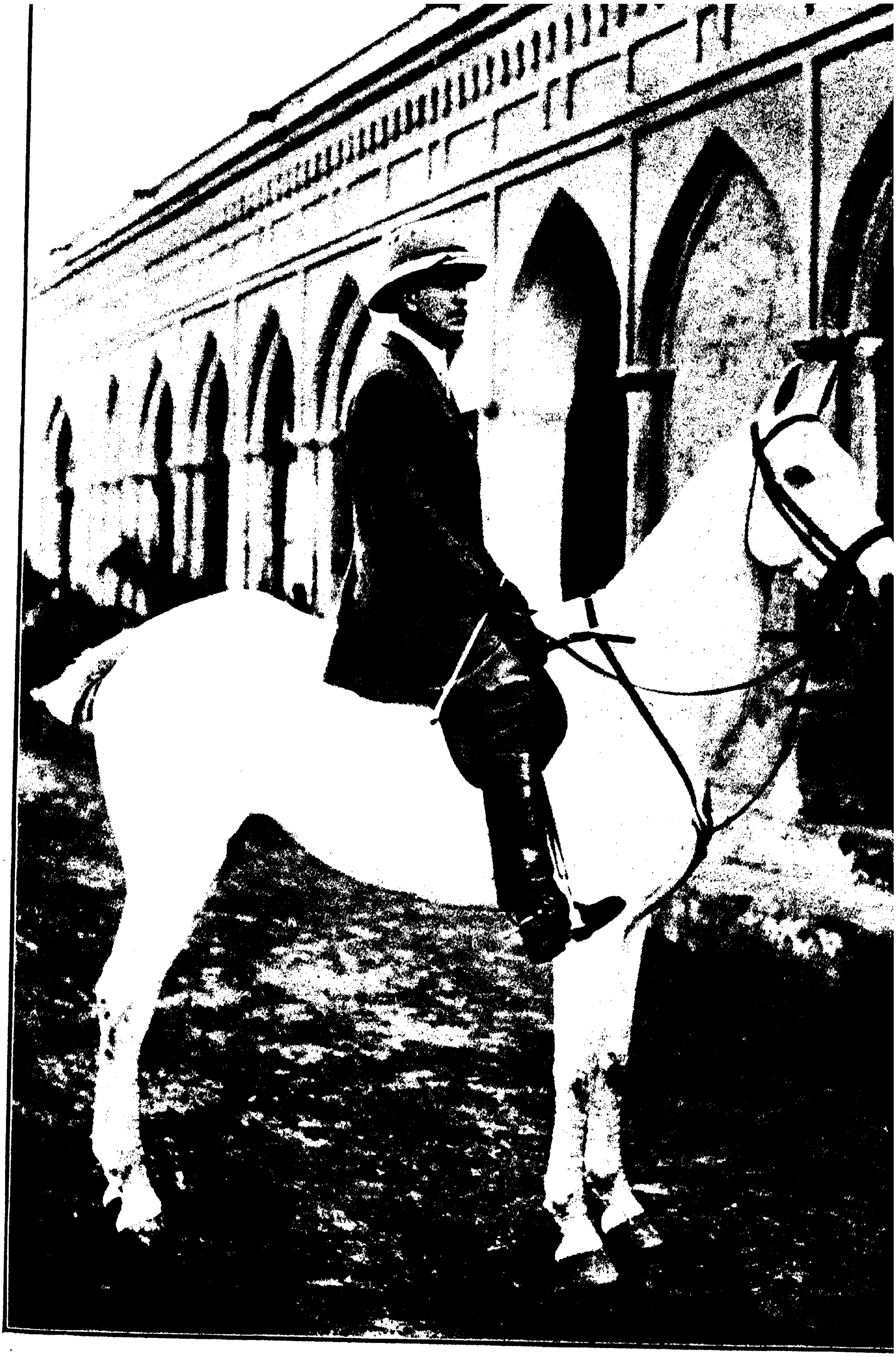
He had the power of communicating his enthusiasm to others. He was passionately fond of all kinds of live stock, and keen as he was on every branch of his work, he was perhaps keenest of all on the subject of cattle breeding. His long experience at Hissar, and later as Chief Superintendent of the Civil Veterinary Department in the province, gave him unrivalled opportunities, and there was probably no better judge of cattle stock in this country.

So enthusiastic was he on this subject that he was even able to rouse the apathy of the Punjabi breeder to some semblance of interest in the subject.

When the Civil Veterinary Department took over the Hissar farm in 1899, the cattle stock were an appalling mixture of breeds. The policy of the Commissariat Department having always been to cross-breed, bulls from Mysore, Ongole, Gujarat, Amritsar, Sind and from every part of India had been continuously imported and crossed on the indigenous Hariana stock. Some fine big bullocks were bred, but the cattle were not of a type to appeal to either the Hariana or Punjabi breeder.

The problem was to evolve from the stock on the farm a type which would be both acceptable to the village breeder, and also capable of exerting improvement. In this work Colonel Farmer was eminently successful; and at the present date it can be fairly claimed that the farm is really in a fair way to attain this ideal. Every year the stock tend more and more to breed true to the type he aimed at.

Problems of disease, etc., had no more terrors for Colonel Farmer than problems of breeding. With the diminutive staff at his disposal, he was always ready to attempt any emergency in spite of the vast numbers of animals and the enormous tracts of country over which he had to direct operations.



Late COLONEL JOHN FARMER, C. I. E., F. R. C. V. S.,
Chief Superintendent, Civil Veterinary Department, Punjab.

He was particularly successful in this connection in diminishing the incidence of glanders and dourine. Early in his career as Chief Superintendent in the province, Colonel Farmer recognized the importance of propaganda, and his lectures in villages did much to open the minds of the cultivators to the importance of effort to improve stock, conserve fodder, and check disease.

He was awarded the C. I. E. on January 1st, 1917. Colonel Farmer was a most untiring worker, with a strong sense of duty. The war added largely to his responsibilities. A large proportion of his staff joined the Army, and he himself undertook extra work, assisting the Army Remount Department in the control of disease in their circles. He had had no leave out of India since 1911, and there is little doubt that his devotion to duty contributed much to his early death.

Colonel Farmer will be much missed in the social life of Lahore. During recent years the annual horse and dog shows owed much of their success to his untiring energy.

He was a good judge of terriers, and a very successful breeder.

R. B.

SOME COMMON INDIAN BIRDS.

No. 7. THE MAGPIE ROBIN OR DAYAL (*COPSYCHUS SAULARIS*).

BY

T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S.,

Imperial Entomologist ;

AND

C. M. INGLIS, M.B.O.U., F.E.S., F.Z.S.

PERSISTENT PESSIMISTS are wont to say that in India the most gorgeous flowers have no scent and that birds have no song, but the Magpie Robin, with many other birds, gives the lie to the latter part of this assertion, as the cock bird has a fine range of melody which is heard especially in the spring. This is one of our most familiar birds, occurring commonly, but never in large numbers, throughout the whole of Continental India and Burma and Ceylon, being especially a bird of the Plains, although it ascends the Himalayas to a height of about 5,000 feet. The cock is a perky-looking bird, rather smaller than a bulbul, glossy black with its lower parts sharply marked off in white, a white bar on the wing and the outer tail-feathers white; it runs along the ground after insects and has a habit of elevating its tail perpendicularly at the end of its run. The hen bird is marked much like her mate but shows greyish-brown in her plumage where his is black. The sexes pair for life and are commonly found in gardens, their habits being very robin-like. They are rather pugnacious birds, a pair generally keeping the whole of a garden to themselves, and the hens are, as Finn observes, of much more retiring habits than their mates. According to Hodgson, these birds are

caged for fighting purposes : "Fighting these tame birds is a favourite amusement with the rich (in Nepal), nor can any race of game cocks combat with more energy and resolution than do these birds."

The Magpie Robin feeds on the ground, mostly on insects, its diet being varied by vegetable matter and an occasional earthworm. The late C. W. Mason investigated the stomach-contents of twelve birds at Pusa and found them to contain 142 insects, of which 7 were classed as beneficial, 50 as injurious and the remaining 85 as neutral, the insects eaten including grasshoppers, crickets, ants, weevils, and other beetles, a few bees (perhaps not taken alive), wasps and cutworms. The injurious insects taken are of far more economic importance than the beneficial and this bird may certainly be reckoned as one of the gardener's friends. I have seen one tackle and kill a Sphingid larva which was almost as bulky as itself.

Breeding takes place from March to July, when a rough nest is constructed in any convenient hole in a tree or wall, but egg-laying takes place in the majority of cases during the second half of April and in May. Very occasionally the nest is placed in a bush, but almost invariably it is found in holes in trees, banks or walls or under the eaves of huts and sometimes in verandah roofs. In the Plains the nest is usually composed of roots, grass, fibres and feathers, but in the Hills moss and lichens are largely used, the nest being saucer-shaped, broad and shallow, four or five inches in diameter with a central depression about an inch in depth. Five is the usual number of eggs laid, but we have seen as few as only two incubated ones, and the eggs are typically oval, neither very broad nor very narrow, averaging about 22 mm. long by 16·5 mm. broad, the ground-colour varying from greenish, greenish-white, to pale sea-green or delicate pale, only slightly greenish blue, but they are generally all streakily blotched and mottled with different shades of brownish-red, sometimes thinly and sometimes so extensively as to leave but little of the ground-colour visible, and in all cases the markings are most numerous at the larger end of the egg, on which they commonly form a conspicuous irregular mottled cap. We have taken one clutch of a pale greenish blue

without a single mark on any of the eggs. The eggs in the same clutch vary very largely in the markings.

Our Plate (Frontispiece) gives a good idea of this bird, the cock bird on the right and the hen on the left, the butterfly represented being *Colias croceus fieldi*, which occurs commonly all along the Himalayas, penetrating into the Plains in the cold weather.

THE EGYPTIAN COTTON PROBLEM.

A REPORT TO THE EGYPTIAN GOVERNMENT.

BY

H. MARTIN LEAKE, M.A., F.L.S.,

Director of Agriculture, United Provinces.

(Concluded from Vol. XV, Pt. VI, p. 615.)

VIII.

I HAVE yet to deal with those subjects which I have termed collateral inasmuch as they are mainly concerned with problems affecting agriculture as a whole and relate to cotton merely as one, though, it is true, the preponderating one, of the crops of the country. The distinction places them in the position of separate and independent sections of the Ministry between which and the sections already dealt with, if formality is to be given to the relations, touch may be maintained through the Ministerial Committee. As I have stated, the subjects lie outside the scope of this report. I will only note here that the relation between mycology and bacteriology in its agricultural bearing is a close one, the methods of research are similar, and the agricultural bacteriologist is, through his training, usually well grounded in mycology. Soil bacteriology appears to be the more urgent line of investigation at the present time and it may, therefore, be found advisable for the moment to unite these two into a single section.

There remains one subject which arises from what has been said under the section dealing with botanical research but which, as it is of wider concern, I have left for separate treatment. In its bearing on the botanical work it concerns the source of the material which

will form the basis of that work. In the course of that discussion I pointed out the hybrid nature of the entire Egyptian cotton crop and indicated the possibility of the spontaneous origin of new and advantageous types as the result of the fortuitous combination, through cross-fertilization, of certain characters. The entire crop is, thus, a natural laboratory and the search for, and preservation of, such naturally arising and improved combinations is most important. The search is of the nature of that proverbial one—the needle in a haystack—and it is a practical impossibility that the botanical staff shall undertake it. Yet it requires to be done. There appear to be two possibilities, in the utilization of Government and private agencies.

The district agricultural staff, developed on the lines indicated, will give a large number of observers scattered throughout the country. In the fields and in the ginneries they will have, from time to time, their attention drawn to plants, groups of plants or to samples of seed cotton, differing from those typical of the locality. It should be the practice for such "finds" to be preserved and the seed submitted to the Botanical Section for trial. In the case of a single plant or an odd "lock" of cotton the seed will be sent to the Botanical Section to be tested for purity and for the establishment of purity, if the progeny prove impure. If it be a group of plants that has been selected, the case falls under the head of bulk selection. In such a case it may be desirable for the circle officer to grow it on himself, for it may prove pure, or nearly so, from the start and, if it does, he will at once be in a position to establish an improved race, thus shortening the introductory process. But he should, in all cases, advise the Botanical Section and give the officers of that section free access to the crop so produced so that they may originate single plant cultures and thus establish a pure stock showing the desirable characters. Bulk selection may give a sufficient degree of purity but more probably it will not. If it does not, the stock will shortly begin to show "deterioration" and by that time the Botanical Section will have eliminated the impurities and worked up a stock of pure seed which can be used to replace the less pure seed which has begun to exhibit signs of deterioration.

The history of the different types of Egyptian cotton which have, from time to time, held the field indicates two facts: the frequent spontaneous occurrence of new forms and the presence in the country of an efficient body of private individuals ever ready to sieze on, and develop, such new forms. The existence of this body is a valuable asset to the country ; it is to the labours of the members of this body that practically all the types of cotton at present under extended cultivation owe their origin ; there is no reason for supposing that their utility is ended. Their activities require encouragement, but, while this is true, it is equally true that their uncontrolled activities are not without danger to the crop as a whole. The wholesale introduction of new varieties scattered throughout the country is dangerous, for such introduction involves not only impurity and " degeneration " of these, but also of the existing crop, both by direct cross-fertilization in the field and by seed mixture in the gins. Thus the new race is in danger of being lost, an undesirable event if it has proved itself to be a real improvement, while the old race is endangered and its subsequent re-establishment, should the new one prove undesirable, rendered a matter of doubt.

The problem is to control the introduction of such new races without removing the incentive to those working towards their production. Now this incentive is the money value derived from the sale of seed during the first few years after introduction. With a name for superiority established and a limited seed supply, the price paid for the available seed is high and remains high until extended cultivation, with increased seed production, removes the main factor from which the profit accrues.* I find that it has been proposed to lay down that the permission of the Ministry must be obtained before such a new race is grown outside the originator's

* I am aware that this statement does not appear to be in accord with the statement made before. The discrepancy is, however, hardly more than apparent. The essential fact is that, in Egypt, the later stages of seed production are nowhere undertaken by the farmer himself. Enhanced prices are realized for the seed of a new cotton which has obtained a name, but the purchaser of the seed of that cotton expects to purchase sufficient to sow his entire area. The extra price he is prepared to pay is limited to the profit he expects to realize directly from the crop he harvested. Profits from new introductions are, thus, limited to the period when there is shortage of supply. There is no continuity in the business such as will lead to the development of a seedsman's trade dependent on a continuous financial return.

estate. Under present conditions application is made to the Ministry only when a bulk of seed has been obtained and it is proposed to start the commercial sale of seed. The Ministry has no definite information as to the value of the new race and, therefore, no means of arriving at a decision as to the desirability of granting a license. Under these circumstances, knowing the danger, it would act wisely in adopting a cautious attitude and refusing a license. But such refusal can but act as a deterrent to those to whom it wishes to give encouragement.

The weakness in the present system lies in the absence of any independent knowledge of the race which will enable the Ministry to decide, and it is at this point that the remedy must be sought. The consideration of the early history of such a race will point to a practical means of attaining the dual object of controlling introduction without discouragement to the producer.

No such race originates as a bulk production ready for immediate introduction. The beginnings are small, it may be a single plant, and some years are spent in working up purity and a stock of seed before the supply reaches a volume to pass beyond the originator's estate. A decision is, therefore, reached with regard to a particular race some years before it is ready to be launched as a commercial proposition. It is at the time this decision is reached that the Ministry should receive information, facilities given to the officers of that Ministry to inspect the crop and a small supply of seed placed at its disposal. That sample will be made over to the Botanical Section and examined for purity and general suitability. From two directions, the botanical analysis and the agricultural inspection, the Ministry will thus be placed in the possession of information on which it will be able to arrive at a decision when application for a license is received.

There appear to be two advantages in this proposal. The demand for early information, facilities for inspection and the submission of a sample of seed require no legal enforcement by penalties. The onus of compliance is placed on the producer and, if he does not comply, he will have no ground for complaint if a license is withheld. The control will not act as a deterrent to the

class it is desired to encourage. Again, the supply of seed will provide the Botanical Section with valuable material for its own investigation—private agency as well as the district staff is, in fact, being enrolled in the search we desire to make as thorough as possible.

It may be necessary to give some form of guarantee that Ministerial development will be delayed for a series of years to allow the originator to reap the benefit of his work. Such a guarantee is not likely seriously to affect the section's work. In the event of a really useful " find " of this nature the slower method, necessitated by the precaution taken to ensure purity, will, in all probability, develop a supply of pure seed at the stage when the financial interest of the originator ceases. The crop will then be relatively impure and Ministerial action will take the form, working through the licensed ginneries, of the replacement of the impure by the pure seed.

The difficulty which has been experienced in recent years both with regard to Zagora and Pelion cottons is traceable to the absence of early knowledge of their existence. The result has been a hesitation in the matter of licensing, which cannot but have disheartened the originator of these. If steps are now taken to procure early information, together with the other facilities to which reference has been made, the difficulties which have arisen in the past should no longer be felt.

In the preceding sections I have reviewed the problem as presented at the present time and it remains for me to extract from that review, in the form of definite proposals, the salient features of a policy which will lead to " the maintenance and improvement of the quality of Egyptian cotton and the increase of its yield." These proposals fall naturally into two sections, the practical, or technical, defining the foundations for such maintenance and improvement, and the administrative, designed to develop those improvements. I omit here any proposals for the establishment of those foundations. That is a purely scientific question, and this report is not the place for a purely scientific dissertation. I have, however, not neglected this matter and have devoted much time to discussing with the officers

concerned the lines of investigation which require to be taken up with this subject in view.

The central fact with regard to the cotton crop, from the former aspect, is that it falls into two groups. The one possesses an intrinsic value, that is, meets a particular need for certain definite physical qualities. The trade requires these qualities in the cotton in order to develop certain qualities in the yarn. Substitution is, in this case, impossible. The second requires no such definite qualities. The only cotton at the present time that falls into the former class is Sakel. It is true that Sakel is used for many purposes not all of which require those intrinsic qualities that it alone possesses, but there is a definite trade of which Sakel alone satisfies the requirements. What proportion of the present production of Sakel goes to meet the requirements of that trade I am unable to say, but, until some other cotton, which also possesses these qualities, is forthcoming, a certain area, not necessarily, nor even probably, approaching the present area under Sakel, must be maintained.

This, therefore, furnishes my first recommendation.

(1) *The maintenance of the purity of Sakel.*

This I consider to be the point of greatest practical importance at the present moment. It has been argued that the decreasing yield of Sakel makes this practically impossible, for it is not possible to dictate to the fellah that he must grow a certain form when it is a foregone conclusion that he will lose by so doing. The argument overlooks one point. Sakel, as I have stated, is used for other purposes than this specialized trade and it is so used merely because it is produced in such quantity that the price is determined, not by its primary, but by its secondary or substituted, use. Were the production to decrease and only that quantity to be produced which would satisfy the primary use, the price would rise until it reached a figure which would make its substituted use impossible. The limits to the price that would be reached from this cause cannot be estimated with any exactitude, but it is probable that the increase would be sufficient to counterbalance any deficiency in yield. There is another factor to be considered here. It was pointed out to me in Lancashire that the

industrial changes of the past few years have so altered the economic position in the cotton industry that the price of the raw material has now become a matter of secondary importance and that there is, thus, a much greater readiness to pay high prices for the raw material than formerly. I am inclined to think, therefore, if this be a true statement, that the market for Sakel will remain even at any price that may be necessary to counterbalance the diminished yield.

The danger to Sakel lies in this. There is no harm, in fact it is probably desirable, that that section of the Sakel crop which at present goes to provide a substituted use should be replaced by a lower grade, but higher yielding, cotton. Such a replacement cannot take place, however, without danger to the entire Sakel crop. Unguided, that replacement might easily end in the disappearance of Sakel as a distinct class. At the present moment Pelion forms a rival which may, at no distant date, replace Sakel as completely as Sakel itself a few years ago replaced Afifi. The latter replacement was not fundamentally unsound, for it was a replacement of an intrinsically inferior, by an intrinsically superior, class of cotton. The replacement of Sakel by Pelion is of the reverse order, and in this fact lies the importance of taking special steps to preserve Sakel.

The preservation of Sakel as one of the standard classes of Egyptian cotton will, no doubt, form one of the items of work of the Botanical Section in that, from it, a series of pure line cultures will be made. But such work is slow and it will take some years to work up an appreciable bulk of seed. The method is likely to be slower than the rate at which Sakel may be replaced in the field if Pelion fulfils the expectations of its admirers. Something more is required and that something will be found in bulk selection. Only by maintaining a considerable area under Sakel and by rigorously rogueing the crop each year will it be safe to allow Pelion to develop uncontrolled. Should Pelion, or, for the matter of that, any other of the new forms now coming to the fore, repeat the career of Sakel, the pendulum is bound to swing too far in the reverse direction and the present complaint in the trade of an excess of Sakel will be followed

by a complaint that there is too little. It should be the policy of the Ministry to prepare for that time and it can do so by some system of maintaining an area of pure Sakel sufficiently large to rectify the balance in a couple of years. It is a very satisfactory feature that the Domains already have this problem in hand and have available a bulk of Sakel seed which is remarkably pure.

Sakel, as has been said, is the only one of the present cottons that possesses an intrinsic value that no other cotton rivals. It has, from the agricultural point of view, however, certain undesirable features. As long as it remains alone as the sole yielder of that especial class, it must be preserved. It is most desirable that this position of isolation should cease at as early a date as possible. This will only happen when a plant with a different habit but possessing the lint quality of Sakel is evolved. Enquiring whether such a plant exists, I have heard Casuli mentioned as a possible substitute for Sakel, but have not had sufficient experience of this plant to form any definite opinion, and its especial fostering, if it does, requires to be placed in the front line of investigation of the Botanical Section. This leads me to my second recommendation :

(2) *The establishment of one or more types with the same intrinsic merits as Sakel but with an improved vegetative habit.*

The especial importance of these two lines of work arises from the fact that Sakel forms, at the present time, the end term of a series of cottons arranged on the basis of intrinsic merit. Sakel can be used as a substitute, but no cotton can be substituted for it in certain of its uses. The remaining outlets for botanical investigation must not, however, be neglected. I may gather these into a further series of recommendations :

(3) *The maintenance of the present classes by a system of purification and establishment of pure races.*

(4) *The development of types agriculturally better suited to the environment, including the demarcation of type tracts.*

(5) *The development of a class of cotton superior in quality to the best Sakel.*

The commercial aspect of these recommendations is given in some detail in Mr. McConnel's note dated 26th July, 1919.

I may now pass to the second, or administrative, aspect. The essential consideration here is the provision of a continuity from the termination of the experimental stages dealt with in the above recommendations to the last stage in which purity of the crop is established throughout extended tracts. This series of recommendations arises from (4) above. The demarcation there indicated can only be made by carefully conducted trials in the various tracts. For this purpose an experimental farm is required in each tract. I may deal with the questions here raised in a series of recommendations :

(6) *The division of the country into circles determined, as far as possible, by climatic considerations and each with its experimental farm.*

In agreement with what has been said in the body of this report, the work of these farms will be of wider scope than is here indicated, and this report is concerned with only one of their functions.

(7) *The establishment of a seed farm in each of the circles so defined.*

The work of these will be the production of a supply of pure seed in sufficient bulk to maintain the purity of the kind when it passes to the less rigid control of general cultivation.

(8) *The introduction of a system of licensing of ginneries for taqawi.*

The system should not be repressive and its main object should be to procure information as to the movement of seed used for sowing purposes rather than to direct that movement into unnatural channels.

(9) *The introduction of a system of licensing persons desirous of introducing new varieties.*

Again, the system should not be repressive and should have as its main object the collection of information concerning the development of such varieties. The main danger arising from uncontrolled introductions of this nature has been the absence of any organized system for maintaining the varieties at the time in general cultivation. When such an organization has been established licenses may be given as a matter of course, for the means of readily eliminating the

cultivation of the variety, should it prove undesirable, and of preventing the adulteration of the existing varieties will be at hand.

In like manner I may summarize the organization I have outlined for the purpose of developing the above.

(10) *The division of the Ministry into a series of sections.*

Such a division is already in existence and I am not so much, therefore, concerned with the principle as with the lines of demarcation. Here, too, I am only concerned with three sections, and I will limit my remarks to these.

The Botanical Section at the present moment administers such experimental farms as do exist. There is also a cadre of Inspectors under an Inspector-General concerned at the present time not merely with district work but with the enforcement of agricultural legislative measures. This latter is, in my opinion, entirely objectionable. It brings the Ministry before the agricultural population as primarily a repressive body whereas its true function is to appear as, and to be, the cultivators' friend. Such police work should be otherwise provided for. With this work removed, the Inspectors will form a body of circle officers under the Inspector-General and form a section comparable with the other sections of the Ministry. Their work will be primarily to gain the confidence of the people, or it is only by so doing that they will be able efficiently to perform the duty of supervising the work involved by the licensing system from the inspection of crops to the marking of the seed. They will be responsible for the experimental and seed development work on the farms of their circle and, if the inspection work is not to suffer, two officers will be required for each circle, the senior undertaking the inspection, and the junior the experimental, work.

This recommendation, then, suggests the institution of an Agricultural Section which will include the present inspectorate. The functions of this section will be limited to the extent that the work of administering such legislative measures as are passed will be removed but be increased to the extent that charge of the experimental and seed farms will be added.

In like manner, the work at present carried out by the Commercial Section is highly specialized and distinct from that of the

Agricultural Section as here defined. This section should act independently and the liaison between it and the Agricultural Section will be maintained through the Ministerial Committee which forms the subject of the next recommendation.

(11) *The establishment of a Ministerial Cotton Committee composed of the heads of the sections concerned and possessing power to co-opt.*

The functions of this committee have been dealt with in the body of this report. One of its main functions will be the co-ordination of the work of the various sections. As I have pointed out, the source of danger lies at the point where development passes from one section to another and particular care must be taken to prevent the encroachment of one section on the field of another. At the same time care must be equally taken to limit the activities of the committee to such co-ordination and to avoid any interference with the actual work of the various sections.

(12) *The establishment of an extra Ministerial Cotton Board.*

So long as the scheme for cotton development entails the joint activities of several bodies which are not all in one Ministry, the existence of an extra Ministerial Board is necessary to provide the necessary co-ordination between these bodies. I have preferred to refer to this as the establishment of such a Board rather than as a reconstitution of the existing Cotton Research Board. The distinction I have already drawn, between the function of the existing and the proposed Boards, will, I think, be obvious. The function of the present Board is "to combine and co-ordinate scientific researches"—a definition which, not inadequately, indicates the function of the Ministerial Committee proposed above—while that of the Board, as I have conceived it, is primarily to co-ordinate practice with the results of these researches. To serve this purpose the constitution requires to be radically altered and the Board should include in its membership representatives of the bodies concerned and not, as at present, members selected on a personal qualification. Probably it will be found to serve its purpose most effectively, if it be established as a purely advisory body reporting direct to the heads of the Ministries or Departments concerned. Its members would, thus, be

drawn from those persons most intimately concerned with the developments of research for which an outlet is required.

The difference between this and the present Cotton Research Board is fundamental. Nevertheless, I do not wish to imply a wholesale and immediate condemnation of the present Board. That Board has, I think, a useful function at the present time. The research staff will be mostly new and lack experience of the country. I would suggest, therefore, that the proposal I have made be considered as an ultimate policy and that, in the meantime, such proposals as arise be considered in the light of such a development so that no steps may be taken which will vitiate their ultimate adoption.

SOME EXPERIENCE WITH POPPY GROWERS IN THE UNITED PROVINCES.

BY

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It occasionally falls to the lot of members of the Agricultural Department in India to introduce some new procedure among a number of cultivators. It is not always easy to determine to what extent the cultivators can be relied upon for honest co-operation.

The present paper gives an account of an innovation required to be introduced among opium poppy cultivators, who received a reward to encourage them to do as desired. Data are given showing the numbers of them who acted up to their obligations and those who did not do so. In this respect it is thought that the paper might be of interest to agricultural readers.

The writer was placed on special duty in 1916 in order to discover the reason why Indian opium was so much lower in morphine content than the produce of Asia Minor and the Balkans. It was essential that India should turn out opium of high morphine content. It was soon found that the method of lancing the capsules was different in India from that used in the other countries mentioned. Whereas in the latter the capsules receive only one lancing, in India each capsule receives successive lancings at two or three day intervals until it yields no more latex, and the total produce is mixed together. As many as five or six successive lancings are taken in some seasons from the same capsules in India. My experiments showed that the morphine content of the opium of each successive lancing undergoes a rapid progressive decrease. Whereas the first lancing might yield 15 per cent. of morphine in the dry matter of its latex, the product of

the fourth lancing would probably only yield about 5 per cent. The problem was therefore to get the cultivators to bring in the produce of their first lancings unmixed with that of their later lancings. Some few weeks after the opium has been gathered, the cultivator has to take it all to a certain centre where a Government opium official takes it over, weighs it and pays for it at a certain rate fixed by Government. In order to obtain the first lancing unmixed with later ones, Government offered a reward of R. 1 to cultivators who would bring their opium in in two portions, one to consist of the produce of the first lancing and the other of that of the subsequent lancings. It will be stated here for convenience of future description that the cultivator usually brings in his opium in earthen plates.

As a result of two seasons' experience it was found that the opium collected from the plates purporting to be the first lancings was not as good as we had reason to expect, though individual parcels gave up to 14·5 per cent. morphine, which is quite up to the Turkish standard. The only explanation of this would appear to be that many of the cultivators were not acting fairly in the matter. They knew they were to get a reward for bringing their opium in in two plates. It is quite likely that many of them would not trouble to keep the product of the first lancings separate from that of the later ones, and would simply divide their total produce into two plates immediately before handing it over to the Government opium officer.

During the past season the writer has carried out a number of tests to check the behaviour of the cultivators. Arrangements were made through the Opium Agent for certain district officers to take a number of samples of genuine first lancings in the field from certain cultivators whose names were recorded. When these same cultivators brought in their two plates for weighment by the opium officer, each of their two plates was sampled. All the samples, *i.e.*, three from each cultivator, were sent to me for examination. The cultivator, of course, when having his opium sampled in the field, was not to be informed that further samples would be taken at weighments. Samples were received from Unao, Rae Bareli, Fyzabad, Fatehgarh, Etawah and Ghazipur. If the cultivator is

behaving squarely, one would of course expect the contents of his first plate to agree fairly well in its morphine content with that of the sample taken in the field, whereas the contents of the second plate should be much lower in morphine content. The following are the results of the analyses :—

Serial No.	District	Cultivator's name	Percentage of morphine calculated on the dry matter of the opium (*i.e.*, consistency 100°)			Remarks
			Sample taken in field	First, *i.e.*, medical plate	Second plate	
1	Etawah	Mangali ..	17·6	13·7	11·2	Doubtful
2	„	Mula ..	13·9	11·8	8·4	„
3	„	Paramsukh ..	11·8	8·7	10·1	Non-genuine
4	„	Kehre Singh ..	15·6	12·9	9·0	Doubtful
5	„	Arjun ..	16·1	14·4	10·6	Genuine
6	Unao	Dayashanker ..	13·1	12·5	8·5	„
7	„	Sheocharan ..	13·1	8·1	10·6	Non-genuine
8	„	Indu, Kachi ..	12·9	12·8	10·9	Genuine
9	„	Pokhai, Kachi ..	11·7	12·0	8·6	„
10	„	Ramadhin ..	10·3	10·6	15·1	(?)
11	„	Khagga, Pasi ..	14·4	14·6	9·5	Genuine
12	Ghazipur	Katwaroo, Lr. ..	14·9	14·1	8·3	„
13	„	Madho, „ ..	16·3	15·4	9·7	„
14	„	Fakir, „ ..	13·0	9·9	11·2	Non-genuine
15	„	Ajodhia, Asami ..	10·0	9·1	7·4	Genuine
16	„	Ramdas, „ ..	15·9	12·0	12·3	Non-genuine
17	„	Sheobarat „ ..	15·4	13·6	10·1	Genuine
18	Fyzabad	......	13·9	12·4	9·4	„
19	„	......	12·7	9·0	10·1	Non-genuine
20	„	......	9·5	[illegible]·8	4·7	Genuine
21	„	......	13·0	13·0	10·5	„
22	„	......	9·9	11·5	6·9	„
23	„	Maharban ..	12·0	10·1	6·6	„
24	Fatehgarh	Durjan, Kachi ..	11·9 *	10·0 *	8·6	Doubtful
25	„	Dalla, Kahar ..	9·5 *	9·3 *	4·3	Genuine
26	„	Palia, Kachi ..	9·1 *	8·3 *	9·1	Non-genuine
27	„	Polandai, „ ..	11·8 *	11·8 *	9·9	Genuine
28	„	Balwant, „ ..	11·2 *	11·1 *	6·7	„
29	„	Parsadi, „ ..	7·2 *	8·9 *	9·2	Non-genuine
30	Rae Bareli	Babu ..	13·8	13·1	9·2	Genuine
31	„	Baiju ..	11·5	10·7	6·3	„
32	„	Lallan ..	12·8	10·5	8·9	Doubtful
33	„	Pancham ..	12·3	10·3	9·0	Non-genuine
34	„	Mst. Surajia ..	13·2	10·6	9·5	„
35	„	Merai ..	10·4	8·8	9·6	„

* The samples taken in the field and those from the first plates were the produce of the first and second lancings combined.

The remarks column shows whether it is considered that the cultivator has behaved fairly or not. Thus, if the first plate does not show a higher morphine content than the second, it is obvious that he has not played the game and has been guilty of fraud. He must in this case have mixed all his opium in the first plate, and when bringing his product in for weighment have divided it into two plates in order to obtain the reward. Occasionally it might happen that a man might have kept the early lancings separate from the later ones, but have subsequently handed in by mistake the later lancings as the first. This would appear to have happened in the case of serial No. 10, where the produce of the second plate gave 15·1 per cent. of morphine and that of the first plate only 10·6. There appears to have been some mistake, however, in the original sample taken in the field in this case, since this only gave 10·3 per cent. morphine. This case has, therefore, been recorded as "doubtful" in the remarks column.

In those cases which are marked as "genuine" the morphine content of the sample taken in the field agrees fairly well with that of the sample taken from the first plate, whereas the morphine content of the sample from the second plate is considerably lower. Typically genuine cases are serial Nos. 9 and 11. Such cases as serial Nos. 5, 13, 18, and 25 are classed as "genuine," where there is a difference of 1–2 per cent. in morphine content between the samples taken from the field and from the first plate respectively but where the morphine content of the sample taken from the second plate is much lower than either.

There are, however, a number of cases where it does not seem that the cultivator has been altogether dishonest, in which there is a distinct difference in morphine content between the contents of the first and second plates and yet at the same time the sample taken from the first plate falls a long way below the standard which one would expect from a consideration of the analysis of the opium sample taken in the field. Such cases are serial Nos. 1, 2, 4, 24, and 32. It may be that the cultivator obtained only a small yield at the first lancing and was afraid that the opium officer would not give him the one rupee reward for such a small amount of opium, and therefore he

took some of the opium from the second plate in order to add it to the first.

Summarizing the results, it will be seen that the behaviour of 35 cultivators has been examined. Only 19 of these or 54 per cent. acted up to their obligations. Ten of them or 28 per cent., either through dishonesty or carelessness, did not attempt to act up to their obligations, and five cases or 11 per cent. must be regarded as doubtful. In the remaining case there must have been some error over the samples.

THE CARE AND TREATMENT OF NEW SUGARCANE IMPORTATIONS.

BY

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INTRODUCTION.

WITH the great simplification in methods of transporting sugarcane material for planting,[1] movements of cane varieties from one locality to another are becoming increasingly common. During the last three months, the Sugarcane Breeding Station at Coimbatore sent out over 170 packages of cane varieties and seedlings to various correspondents. This article is written to give a wider publicity to the methods employed at this station in the matter of the rather detailed and personal attention which such importations require during the first years of trial.

When one reads of a promising variety in any locality, it is an easy thing indeed to dash off a letter to the place of origin for a supply of the material, but the need for proper attention and care during the first few years is not always adequately realized. A bad stand, often due to lack of sufficient attention during the early stages, inevitably postpones the testing by a year, and the enthusiast

[1] Venkatraman, T. S. "Packing Seed Sugarcanes for Transport." *Agri. Jour. of India*, XV, Pt. II, March 1920.

is filled with disappointment at the additional year of waiting required. This is often due to lack of time or staff, especially in farms where other crops occupy a more important position; but the old adage, "If a thing is worth doing, it is worth doing well," holds good in this as in many other cases.

The parcel and its opening.

The transport agencies, be they rail or steamer, are not generally over-careful in the handling of such packages, and it is a good plan to stow away the parcel as soon as received in a cool shady place. Even with the best of packing, labels have been known to get displaced in transit; it is therefore desirable that the unpacking is done in the immediate presence of a responsible officer and with an expectant attitude as to such possibilities. A certain amount of system followed in the unpacking—the sender cannot but follow some system—has been known to save varieties from being lost for planting, through the displacement of labels in transit. Should, however, a doubt arise, it is far better to discard the lot, rather than plant it out, under a possibly wrong name, to be a continuous enigma to all concerned.

The parcels should be opened as soon as possible after receipt, for they often contain buds in advanced stages of germination, and these are liable to be lost for planting, should the unpacking be long delayed.

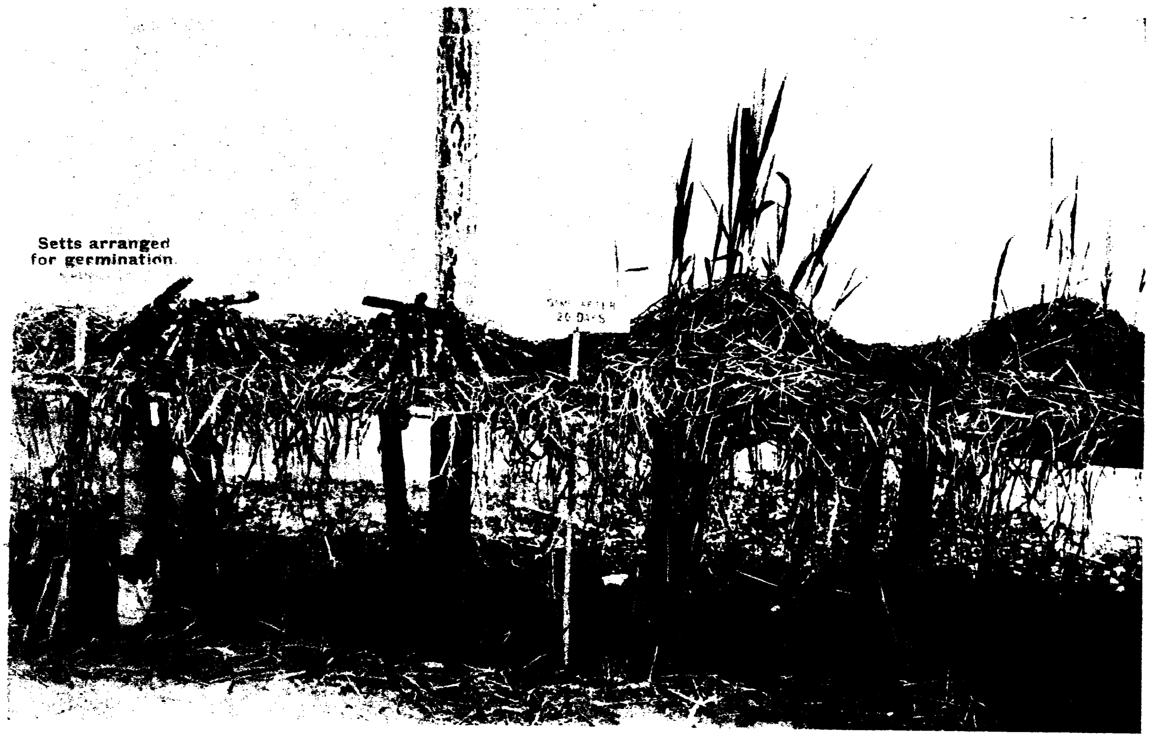
Before the actual opening of the parcel, care should be taken to see that the land to receive them is ready for planting. In the case of oversea consignments, where the material is often of a very limited character—frequently consisting of two to three live buds—it has been found a good plan to plant a set of buds in large-sized pots (1′6″ high and 1′6″ diameter at top), to guarantee reserve material, should those in the field fail to germinate, as pots are easier to take care of than plants in the field. These pots should be carefully prepared with potting-earth, bottom one-third filled with sand and stone pieces to help in drainage, raised over pieces of brick and the drainage-holes carefully tarred to prevent the entry of termites, and the name of the variety clearly written on the outside of the pot in

white-paint and enamel to prevent its getting rubbed out. The cane plants grow luxuriantly in these, and at the station one of these pots has been known to give as many as 168 buds for planting at the end of one year.

EXAMINATION OF THE MATERIAL.

After unpacking, the pieces should be carefully examined for any disease that may have escaped the notice of the sender and developed *en route*. The cane piece in transit, carefully protected at the ends from desiccation, apparently forms an ideal culture house for the full development of any disease, chiefly of fungoid origin. In the case of oversea consignments, where there is a considerable risk of importing new diseases along with the cane material, it is essential that the material, before planting, should be passed by a competent entomologist and mycologist, as the unwary introduction of a new disease into a locality will often more than counterbalance any good that may ensue by the introduction into cultivation of the new variety or seedling. It may appear rather hard to have to destroy wholesale a variety which it has taken a certain amount of strenuous correspondence to import, but the interests of the industry as a whole requires to be safeguarded by every possible means, and the example of Java, where the industry was brought to the brink of extinction by a single disease, should reconcile one to the thorough examination advocated above. Very recently, a whole consignment of such imported material, which, owing to the free rooting and shooting, appeared quite healthy, was condemned by the mycologist, as it showed a fungus not common in this country.

Ultimately, all that is needed for planting is the bud with the immediately adjoining root-zone, and portions of the internode, which have become sour or rotten during the transit, should be carefully removed. Such a deterioration is confined solely to oversea consignments, which have been delayed in transit and have been found to affect prejudicially the germination of the buds. Some of the imported varieties now at the station have resulted from single buds saved in this manner.



METHOD OF GERMINATING SUGARCANE SETTS ON RAISED BAMBOO PLATFORMS.

Preliminary germination of the material on special bamboo platforms.

Should the land to receive the material be not ready, or should there be room to apprehend that the buds may be destroyed by termites during the early stages of germination, the following method is recommended[1] (Plate II).

A raised bamboo platform is erected at a convenient height from the ground, say, 3 feet. A thin layer of straw is spread over it and sprinkled over with thick cattle dung solution. The cane pieces are now dipped in the same solution and are arranged *irregularly* and in a heap over the layer of straw. The irregularity in the arrangement of the cane pieces secures a certain amount of air in between the setts, a necessary condition to satisfactory germination. The heap is again covered over with a thin layer of straw dipped in the solution and kept moist by careful and repeated waterings. A paper label, bearing the name of the variety and treated with paraffin as described in a previous article,[2] is secured to the bamboo in front of the heap by means of a paraffined string. When a large number of varieties are placed for germination on the same platform, a sufficiency of space should be allowed in between the adjacent heaps to prevent chances of a mix-up. In about 12 days the buds are seen to germinate freely and the best time for planting these out has been found to be about 20 days after the start; but the germinated plants can be kept on these benches for as long as 50 to 60 days. The supporting posts are smeared with tar, crude oil emulsion or some other deterrent to keep off ants and other insects.

In all the operations described above, as also in the actual planting in the field, it is a sound plan to finish off the variety on hand before the next one is taken up. The operations described above are so simple that any careful cooly could be trained to do it, but they are so important that they should be done in the presence of a responsible officer.

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[1] *Leaflet No. XX of* 1911, *Dept. of Agri., Madras.*

[2] Venkatraman, T. S. "A few Hints on Labelling in Experimental Stations." *Agri. Jour. of India*, XV, Pt. I, January 1920.

PRECAUTIONS AGAINST WHITE ANTS.

Belated reports have occasionally been received that the bulk, or even the whole, of the material sent out from this station has been lost in the field through an attack of white ants. Such losses are specially serious in the case of new importations and justify the detailing here of the methods employed at this station against this pest with a fair amount of success. Deep, thorough and repeated cultivation has been found the most effective remedy against this pest; but there always turn up instances where the cane planting could not be delayed till the land is brought to this condition, and in such cases elaborate precautions are apparently indicated.

Pieces of half-rotten cattle-dung, not infrequent in manure purchased from outside, and all fibrous material offer special attractions for this pest and are to be carefully removed from the trenches before the planting.

Steps are then taken to impregnate the soil surrounding the cane pieces with some repellent. For this purpose, before each irrigation, the trenches are sprayed with a weak solution of crude oil emulsion—one lb. of emulsion to 10 gallons of water. The irrigation water, as it sinks down, carries with it the solution and surrounds the planted setts with it. Besides, the pieces themselves are dipped, immediately before planting, in tar-water,* which is prepared by boiling water in an earthen pot and adding to it coal-tar, drop by drop, at the rate of about two to three drops to every gallon of water. The tar imparts a characteristic smell to the whole of the liquid. The tar-water should of course be cooled before dipping the setts in.

White ants are very quick in their work of destruction and the fields, if at all infested, should be inspected as often as possible—every morning in the earlier stages—and crude oil emulsion or tar-water applied to the trenches as often as necessary. Frequent irrigation is by itself a good deterrent, but if

* This was copied from some other country, probably Australia. The exact reference is not available.

PLATE III.

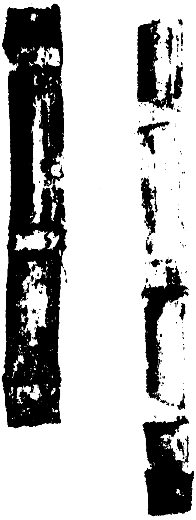

Fig. 1

Fig. 2.

Fig. 3.

SUGARCANES DAMAGED BY WHITE ANTS.

Fig. 1. shows the commencement of the attack on planted setts.

Fig. 2. illustrates a more advanced stage in the attack.

Fig. 3. is a picture of the basal portion of a mature cane which attracted attention because of the withering at the top. Only the rind was left and the centre was filled with mud. A portion of the rind has been removed to show the mud inside.

PLATE IV.

Fig. 2. Local method of smoking rat-holes.

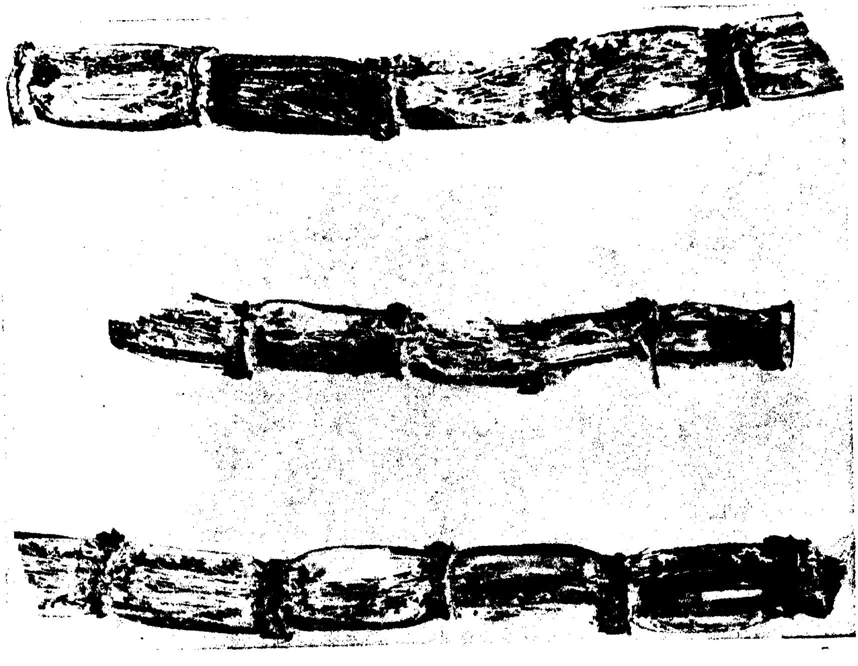

Fig. 1. Pieces of sugarcane badly damaged by rats.

carried too far, the plants turn pale and become unhealthy. Tar water is much cheaper than the crude oil, but the latter is more efficient.

The ravages from white ants are by no means confined to the earlier stages. Instances are known where even when the canes were fully mature, the white ants had eaten up the centre so badly as to leave only the rind, giving rise to canes quite normal in external appearance, but filled inside with mud instead of with the juicy cortex and pith (Plate III, fig. 3).

CARE OF CROP.

Because of wide variations in the times of planting and harvest in the different cane countries of the world, such importations often arrive at the wrong season and are relegated to some hastily prepared corner of the cane plots. This should be avoided, a careful eye kept on the maturing canes, and suitable precautions taken against any pests or diseases to which these are specially liable during the early years of acclimatization.

Rats are a serious menace in most cane plantations. The enormity of the damage is often suddenly realized when a large number of cane clumps in a field, which have been burrowed all round by these creatures, come down suddenly soon after a heavy rain or wind. A certain amount of cleanliness of the plots, consisting of the careful removal of all trash and other rubbish that accumulate under the cane clumps and the propping of all lodged canes, greatly helps by lessening the places of shelter for these creatures. Whenever the damage is extensive, considerable help could be derived by systematically smoking the rat-holes by means of a white-ant exterminator and sulphur fumes described in a note by Mr. T. F. Main, in the "Agricultural Journal of India," Vol. XI, 1916, pages 82–85. Round about the station there is a class of people who relish these for food and secure them for their table by smoking the rat-holes with the very simple apparatus pictured in Plate IV, fig. 2.

An earthen pot filled with dry cattle-dung cake and allowed to smoulder, is seen just beginning to give off smoke. The boy to the

right has selected the hole for smoking and has closed up all other exits with wet mud. Further, he has inverted the smoking pot over the selected hole, plastering it all round with wet mud, to prevent the escape of smoke, and is ready to blow the smoke into it by applying his mouth to the tiny opening at the bottom of the pot. A few dry cattle-dung cakes and three of the day's victims are seen in the foreground. The cost of the outfit is very little as the pot costs but half an anna, and lasts at least a month. The cattle-dung cakes are gathered by the roadside. The smoking described above does not kill the rats but only stupefies them. These try to come out, when they are easily caught by the other cooly on the watch. Two coolies, belonging to this particular class and costing 12 annas a day, have been known to do about an acre per day. This operation requires to be repeated at intervals.

The white-ant exterminator and the sulphur fumes method referred to above are about eight times as effective as the local method.

PRELIMINARY TESTS FOR SUITABILITY.

It is important that information about the behaviour of the new arrivals should be available as early as possible. It is desirable, therefore, when there is sufficient material, to start the chemical analyses of the juice earlier than for the rest of the canes and continue it later. This will yield valuable data about the "early" or "late" character of the importations, a quality of considerable importance in the introduction of a new variety into a locality.

To form any useful opinion about the introductions, a large field scale test is desirable and steps should be taken to bring them into this condition as early as possible. Good germination and stand in the cane plots are best secured by using for planting portions of the cane which contain a relatively large amount of glucose, such as the top halves of mature canes or immature canes. It is remarkable how quickly cane material could be multiplied. In the experience of the station it has been found possible to grow in a period of two years one-tenth acre plots of varieties for which only about forty buds were received at the time of importation.

Lastly, it is essential that a new introduction should be tried for a series of years before being finally condemned as unsuitable. A variety called "Fiji B," which during the first years put up a poor show in the estates attached to the factory at Nellikuppam in South India and would have been long ago condemned by a hasty superintendent, is now considered the most promising cane for that locality.

FORESTS AND IRRIGATION: A PLEA FOR SCIENTIFIC PRESERVATION AND GROWTH OF STATE FORESTS AND SPECIAL CULTURES.

BY

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THE importance of forests to all civilized nations was emphasized by the late President Roosevelt in his address to the American Forest Congress assembled in 1905 to discuss ways and means of stopping the rapid deforestation going on in America. After some preliminary remarks the President observed: "The great industries of agriculture, transportation, mining, grazing, and of course lumbering, are each one of them vitally and immediately dependent upon wood, water, or grass from the forest. The manufacturing industries, whether or not wood enters directly into their finished product, are scarcely, if at all, less dependent upon the forest than those whose connection with it is obvious and direct. Wood is an indispensable part of the material structure upon which civilization rests, and it is to be remembered always that the immense increase of the use of iron and substitutes for wood in many structures, while it has meant a relative decrease in the amount of wood used, has been accompanied by an absolute increase in the amount of wood used. More wood is used than ever before in our history."

In sounding a note of alarm against wilful destruction of forests Mr. Roosevelt remarked: "If the present rate of forest destruction is allowed to continue, with nothing to offset it, a timber famine in future is inevitable."

We may well ponder these remarks, considering that the extension of the forest area and preservation of existing forests

on which so much emphasis is rightly laid by the State Forest Department are regarded by the revenue officers of the State as the chief items of grievance against the Forest Department! Apart from economic reasons, the physical conditions, too, of this State require a sound forest policy. All the big streams of the territory are, year by year, carrying away good top soil to the Ganges, the water courses are being deepened, and the subsoil water level is being perceptibly lowered; old wells require deepening almost every two or three years and the cost of sinking new wells is greatly increasing. Rainfall conditions are getting more and more uncertain, with the consequence that agriculture has become a game of chance. Drought and famine, instead of being occasional intruders, are becoming familiar, though unwelcome, visitors! Every third year in Gwalior we are confronted with scarcity, and large moneys have to be spent to afford relief to the ryot, who lives from hand to mouth and has no staying power. Gwalior is rich in mineral resources, but we have neither coal nor enough wood to exploit them economically! A large portion of the State is lying uncultivated and covered over with inferior jungle. If this very area were covered with trees yielding useful timber, we would not require to import timber from outside; the fuel problem will be less acute and, what is more important, we will not have to burn cowdung cakes, a valuable manure, in large quantities every year! It behoves us therefore to set about thinking how this undesirable state of affairs can be modified.

There are many ways of developing the resources of the State, which it is not necessary to dilate on here. I shall only consider the introduction of a sound forest policy, in which irrigation will play no mean part. To bring into prominence the importance of silviculture, and the great impetus that can be given to it by the Irrigation Department, it is first necessary to consider some of the issues involved.

Rainfall.

In a semi-arid tract like Gwalior, the rainfall plays a very important part. If the rainfall is sufficient and well distributed the harvests are satisfactory, the cultivator is happy and there is not

much difficulty in realizing land revenue. Should the rains fail or be badly distributed, immediately famine conditions supervene, the land becomes parched and dry, crops wilt, fodder withers, the cattle starve and die in numbers by hunger and thirst, and the famishing ryot forsake their holdings in search of food, many die in the way and few return to resume their agricultural pursuits. This has been going on for untold ages and accounts for the sparseness of population in Gwalior. At present the means of conserving moisture are inadequate. Gwalior is no doubt the best protected State in Central India and has about 1,000 tanks varying in capacity from 50 to 10,000 million cubic feet, but these hold back an infinitesimal portion of the total precipitation. Even if the constructional activity goes on on the present lines, it will be decades before any appreciable storage can be effected. "The solution," as Mr. Lippincott, of the United States Reclamation Service, remarks, "of the problem of storage of flood water is not in retention of a small percentage of the storm waters behind dams, but in applying storage on the entire watershed (*i.e.*, the catchment basin) by the systematic protection and extension of forest and brushwood-covered area." This points to irrigation and forests working in collaboration, with a view to extending the forest area by systematic plantation, wherever, as in the vicinity of irrigation works, it can be effected economically. Only very recently have the ryot learnt the advantages of irrigation in agriculture, and it yet remains to be discovered that if the irrigation works were taken advantage of it will not take long to develop our forests rapidly.

RUN-OFF.

Run-off is the portion of rainfall which rushes into the outfall and thence to the sea. At present a large percentage rushes off immediately on precipitation, very little going into the subsoil to feed the springs. This is not only a direct loss of so much precious fluid, but in its mad career from the high to the lower lands it works incalculable havoc in the following ways :—

(*i*) In washing off finer particles of soil and thereby impoverishing the cultivable land.

(*ii*) In increasing the ravines and contracting the culturable area, slowly but not the less surely.

(*iii*) In deepening the streams and lowering the subsoil water level. This point has been well brought out by Mr. Sidney Preston, C.B.E., C.I.E., M.I.C.E., in his lecture at the Ajmer College, to which I invite a reference.

(*iv*) This annual rush-off has also a great effect on the physiographic form of the land. If the process of denudation is allowed to go on, the land becomes precipitous and sloping, whereas if this denudation is not in play the slopes are gentle and the agricultural land absorbs a very great proportion of the precipitation. The ravines of Chambal afford an object lesson. Not only have lakhs of acres been destroyed by the ramification of its ravines, which are gaining yearly on land under cultivation like the tentacles of an octopus, but the fields in their vicinity are becoming coarse grained and are being covered over with pea *kankar*. To our accustomed eye the damage which is going on is not apparent, but if an accurate topographical map of the locality had been prepared a couple of centuries ago, its contrast with the present map would have been something more than startling. In his lecture on the importance of the forest to agriculture, the Hon'ble John Lamb, of the American Congress, observes : "It is claimed that about 200 square miles of fertile soil are washed into the rivers annually in the United States, while the loss in crops and other properties destroyed by floods will run up into millions." This applies with equal force to India.

The above will give some idea of what loss the run-off is doing. To avert this havoc two things are necessary : (*i*) conservation of rainfall by reservoirs, and (*ii*) extension of forests in all regions, where, for some reason or other, cultivation is not possible at present. For instance, if the population is very sparse in any region, it is

idle to reserve land, from settlement to settlement, for cultivation in the hope of an increase in population ! Increase of population is a function of prosperous conditions and not, as it is generally believed, prosperous conditions the result of population necessarily ! If the conditions of life are made easy and food available in abundance, man multiplies apace. A reasonable margin of cultivable land near existing holdings may be reserved for further expansion of cultivation but the greater portion, at present wild waste, should be turned into timber forests and systematic plantation done ; but nothing can be done till the angle of vision of the revenue officers and the ryot changes ! Nothing can be done without their active support. The Forest Department should regard it as their principal duty to educate public opinion as to the importance of forests in the human economy. People should be taught to regard forests not as a necessary evil to be tolerated till agriculture advances but as an end in itself. Forests require to be protected from all encroachment from the Revenue and the Agricultural Departments and developed for their products as much as for the preservation of land from denudation, and to obviate intensification of aridity.

NATURE'S RESERVOIRS.

It is claimed for forests that they lead to greater precipitation of rainfall, and we may well hope that by the extension of forest area rainfall conditions will improve. This, however, is not so important as the direct conservation of moisture by forests. A great portion of the rainfall, in a thickly covered forest, is absorbed by the leaves. Of the balance which falls to the ground a considerable portion is caught up by the leaf mould and sheddings of the trees and undergrowth, which hold it prisoner for a considerable period, and if the precipitation is incessant and extends over a long period, reluctantly as it were they allow a small portion to go to the outfall, but the excess escapes gently and keeps up a slow though steady discharge. What the streams lose in amount, they gain in steadiness : instead of the surplus rushing off torrentially to the sea, leaving the drainages dry within a few hours of rainfall, the amount escaping is very much smaller, but continues for months—the forests act as Nature's

regulating reservoirs and flood moderators! No fine particles are allowed to be carried to the sea, and in consequence of the slow rate of the run-off a very considerable portion of the precipitation finds its way into the subsoil and helps to raise the water table. The deepening of the water courses, if not altogether stopped, is greatly minimized. Agriculture is benefited by the steady flow which lasts to beyond the *rabi* season. The presence of moisture in forest areas tends to keep the temperature low, not only within the forest, but for miles around. This greatly modifies the climate which is rendered more equable, and in consequence of this hygienic conditions improve. Trades and industries dependent on forest produce flourish, work is found for thousands of men, and the cause of civilization and humanity is advanced. The State is directly benefited in the increase of revenue and indirectly in the prosperity of its subjects.

A sound famine protection policy cannot ignore the importance of conserving moisture by construction of irrigation works and extension of forests. Even though in years of scarcity tanks do not fill to the brim, they exercise a most beneficial effect on the land under command and the ryot within their sphere of influence. Their presence makes for stability and keeps the ryot from losing their heads and getting demoralized. Forests also come in handy: they supply fodder and water to the starving cattle, and men also find in the hospitable regions of forests something to fill their stomachs with. The loss of cattle in the famine of 1905-06 was something terrible, but it was mainly due to the munificence of His Highness the Maharaja in throwing open forest reserves to the public that a small percentage of cattle could be saved!

The Gwalior State has got immense possibilities of extending irrigation, and wherever there are irrigation works plantation of fruit and timber trees is easily possible, owing to the presence of moisture. There are about 1,000 State tanks, large and small, round about which plantation of valuable timber trees can be done with a small cost. This task is specially easy in black cotton soil tracts. On Akodia tank (Pergana Shujalpur) I saw numerous sandal trees growing naturally some 10 years ago. Their value was not realized by the local zemindars who cut the immature trees for petty gain.

If cultivation of sandal trees were extended in Malwa, it would be found to be very paying. .

In view of the gradual disuse of opium in China and consequent slackness of demand for it, poppy cultivation is much restricted. This has seriously affected the revenues of Malwa ; it is very necessary, therefore, gradually to introduce other high paying plants like sugarcane, tobacco, cotton, rice, etc., for which irrigation affords all the necessary facilities. Sugarcane requires an assured supply of water. Now that big reservoirs are being constructed cultivation of sugarcane can be largely extended.

As regards the future of tobacco in Gwalior, as elsewhere in India, I quote the following extract from a note on the growing of tobacco in India for the European market published in the "Agricultural Journal of India," Vol. III, Part IV :—

"Out of a total area of 220,000,000 acres under crops in British India and Native States, over one million acres are under tobacco. This figure is probably well under the mark. No statistics are at hand to show the value of this crop, but if we take the figure of £5, or Rs. 75 per acre, as representing the gross yield, we have a trade equal to over 5 million pounds sterling, which would bring it into the fifth or sixth position of importance among the crops of India."

Some revenue officers labour under the idea that unless water is guaranteed all the twelve months of the year raising of high class crops is not possible. I have tried to combat this idea in my paper on development of high class cultivation in Malwa. Besides, sugarcane is extending steadily in Sabalgarh and Bijeipur Perganas though I guarantee no water in April, May and June. During these three months the demand for water is keen and is met by digging *kacha* wells, which is economically feasible, owing to the subsoil in the vicinity of irrigation works being highly charged with water and which can easily be tapped.

Now that the State boasts of a well-equipped Agricultural Department and the Forest Department has secured the services of a Forest Expert and also a Chemist of Mr. Puran Singh's calibre, and the Irrigation Department is doing its little bit, an era of intelligent co-operation between the allied Departments of Revenue, Irrigation,

Forest and Agriculture should be ushered in. The millennium will never come by pious wishes but by active translation of these wishes into acts under the guidance of experts of the several departments. Indians have yet to learn that co-operation does not consist in meddling in others' affairs and constantly exercising the critical faculty but in constructive co-operation and intelligent accommodation. India is on the eve of emancipation. The States should have their full share of this glorious opportunity, and put their houses in order. Being less trammelled by red-tapism and officialism, they are more free to introduce wholesome reforms and see their fruition long before the highly organized and unwieldy machinery of the Imperial Government permits it in the British provinces.

SOME LOCAL PRACTICES PREVALENT IN SOUTH INDIA IN THE CONTROL OF INSECT PESTS. *

BY

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THE existence of insect pests and the trouble some of them often give have been known in South India from time immemorial, and I fancy it is the case almost everywhere else. It is also not unknown that in different parts of the country various ideas are entertained as to the origin and nature of pests, and often numerous local methods are in vogue to check insect depredations. Now that scientific methods are being adopted to investigate the nature of these pests, and attempts are made to devise control measures on a scientific basis, I believe it might be interesting, and perhaps useful, to have some idea of the local beliefs prevalent in different tracts regarding insect pests and the various rural methods practised to control them. It might also enable us to examine whether any of these practices, many of which, however, are apparently empirical, crude and often meaningless, bear any scientific relation to the different modern methods suggested by entomologists, and whether any of these are of any real value to be encouraged. In brief, it would give us an idea how Indian farmers and house-holders of the old days stood in relation to insect pests. A fair amount of touring into some of the rural areas of the Madras Presidency for over a decade, and some close familiarity with the various reports of pests received

* A paper read at the Nagpur Session of the Indian Science Congress, 1920.

by the Agricultural Department officially from time to time, have enabled me to make some observations and gather some information on this aspect of the subject, and I am just attempting in this paper to describe very briefly some of these indigenous beliefs and practices, chiefly with the idea of getting some information in this line from workers assembled here from other parts of India.

With regard to the various local beliefs entertained by villagers as to the causes that bring about insect outbreaks, we can find, unfortunately, very little of scientific tinge in them. The chief of these are God's curse, the alleged bad position of the planets for the season and the prediction of a local oracle or astrologer, the displeasure of a particular village deity who was not properly propitiated, a neighbour's black art or evil eyes, the approach of a polluted man or woman, a bad wind, floods, sudden and unexpected changes in the weather, and a number of other causes real and supernatural. It need hardly be stated that, with the exception of some of these which are quite evident, few of the above would generally appeal to scientific men and could therefore be brought within the realm of practical politics. However, one or two interesting points with regard to some of the prevailing local beliefs on the origin of crop pests may be mentioned here. The appearance or disappearance of insect pests is very often associated in different parts of South India with the appearance and the direction of the winds; this is especially the case in the delta tracts of Godaveri and Kistna; the *payirgali* and the *thoorpugali* have their own significance and are regarded as very important by the agriculturists. A good deal of stress is also laid on the time of sowing particular crops to avoid pests, and I have heard from experienced and educated ryots that in some cases early sown fields, and in others late sown ones, suffer from pests. Such beliefs are entertained in many places and are probably the conclusions of years of experience, and as such we are not yet in a position to belittle them though convincing scientific explanations for such phenomena have not yet been found out to confirm such views.

Now, coming to the control measures adopted, we might consider these under the following convenient heads :—

RELIGIOUS OR FAITH CURES.

In most villages many of the farmers, believing as they do in supernatural causes of insect outbreaks, naturally do nothing; they think that the curse of God should run its natural course. At the same time there are others who resort to faith cures such as charms, *mantras*, magic, and so on, in the belief that the curse may be avoided or cleared. Most of these methods consist in getting the professional local soothsayer or magician to perform some ceremonies to drive the pest and save the crop. While once in the South Arcot District in connection with the study of the leaf miner (*Surul*) pest of groundnuts, I came across a professional pest driver who reluctantly wrote me out a Sanskrit couplet, which he told me in confidence was very effective in checking pests. The verse is to the effect that all sorts of pests can be driven by means of a talisman prepared and fixed by an individual born of a particular *gotra* or sect among *dwijas* or the twice-born. The procedure consisted in this man preparing three small slips containing the verse written down and having these buried at the three corners of an infested plot on a Sunday morning. It is believed that the pest clears out through the fourth corner of the plot. I have given this one instance just to give an idea of some of these ludicrous methods in vogue. I am told that in parts of Cochin and Travancore, when paddy fields are infested with pests like the rice-bug, etc. Christian ryots often resort to the method of sprinkling on the infested fields sanctified water obtained from Catholic priests. To ward off the effects of the evil eye which is said to produce injury or disease to crops and in which many literate people have faith, there are curious devices employed in different places. Very often a field with a promising crop, if it happens to be situated by the side of a thoroughfare, is often protected from the evil eye by the prominent exhibition of some curious object in the middle of that plot, such as a skull, a dead crow, a stuffed figure of an unnatural man or woman, a painted pot on a pole, etc. (Plate V, figs. 1 and 2.) In gardens where betel

PLATE V.

Fig. 1. A painted pot in a field to ward off the evil eye.

Fig. 2. A scare crow in a field of Sorghum.

Fig. 3. Use of bamboo umbrella in sweeping the swarming caterpillar.

Fig. 4. Covering of fruits with paper bags to prevent insect attack.

vines and grapes are grown, visitors are not usually allowed admission, and in the former case never with one's shoes on. While inside a betel vine garden once in the Tanjore District, where I was reluctantly allowed admission by the owner, I just overheard a conversation to the effect that no higher caste man should be allowed into a betel vine garden, because the garden will suffer from the evil eye. Some of the local methods reported to be resorted to in villages in some parts of the North Arcot District against caterpillar pest on paddy were the sacrifice of a goat to the village deity and making cooly girls perform a ceremonial dance near the infested field. The various harvest festivals called *pongals*, *pujas*, etc., performed as thanksgiving for a good crop, and prayers for a future good crop, are also said to have some significance in keeping off insect pests.

In spite of the funny and curious nature of many of these methods, many cultivators still have faith in these cures and cling to those practices. One reason for this, so far as I have been able to make out, is this : In some cases of pest outbreak, such as swarming caterpillar, the time of the sudden disappearance of these creatures into the soil or otherwise due to their peculiar habits synchronizes with the apparent inactivity period soon after some faith cure is adopted.

We will now come to consider other local methods which appear to be of a practical nature. Though many of these are carried out in most cases without the knowledge on the part of the ryots as to their bearing on insects or on their habits, some of these practices have been found to produce the desired results.

CULTURAL METHODS.

Weeding. Very few farmers will admit that they carry out this process of weeding to check insects ; but in effect this method goes a good way in checking insect pests. I know that in parts of South Kanara, in the villages along the Ghâts, where the rice-bug is a bad pest, the cultivators believe that periodical burning of the jungle grass around their paddy fields reduces the pest considerably, and there is a good deal of scientific truth underlying the same.

Flooding. In parts of the Godaveri Delta, flooding of paddy fields is adopted to check swarming caterpillar (*Spodoptera*) attack. In some villages of the Coimbatore District, the same method is resorted to in betel vine nurseries where the young *Sesbania (agathi)* plants are attacked by the caterpillar *Prodenia*. In both these cases, the result is effective and brings up the caterpillars which become a prey to insectivorous birds of sorts.

Draining of water. This is believed to check rice Hispa in some villages of South Kanara. I have also read of this practice in parts of Bengal for the same pest. I am not quite sure as to whether this practice does not prevail in some places in the treatment of the rice-case worm (*Nymphula*) also.

Selection. In the well-known tobacco areas in the Godaveri *lankas*, before the seedlings are transplanted into the fields from the nurseries, there is a system of weeding-out sickly seedlings and those that show a sort of swelling at the stem which is caused by the stem-borer of tobacco (*Phthorimœa heliopa*) ; many of the tobacco growers are familiar with the pest and this sort of selection is found to do immense good. But what unfortunately lessens the good effect of this intelligent measure is the rather imperfect way in which the discarded seedlings are disposed of ; they are not destroyed but left on the field bunds, thus helping many of the borers in these stems to live on and infect healthy fields.

Growing of mixed crops. Just as weeding, this is also a very well-known and common practice in many dry land tracts, and, as in the case of weeding, it is doubtful whether the cultivator ever thinks of insect pests in this connection. However it be, there is no doubt that this mixed cultivation of different crops certainly contributes its own share in reducing insect pests.

Seasonal ploughing. Though this is not done regularly with special reference to the control of insect pests, in most cases there is no doubt that this method has its own insecticidal value—especially when it is done after an attack of hairy caterpillars, grasshoppers, cockchafers or cutworms. In South Kanara, when small plots of paddy are badly infested with Hispa in the third crop plots, the farmers plough up the field and sow pulses.

III. Mechanical methods.

In different parts of the country when farmers find that their infested fields are still bad in spite of all faith cures and agricultural methods, they resort to the trial of various mechanical and other methods of a practical nature. Among these are :—

Netting, bagging, etc. For pests like locusts, rice-bug, swarming caterpillar, etc., it is a well-known practice in parts of Malabar and Travancore to destroy these by collecting them in bags, nets, winnows, etc. Though worked on the same principle, the contrivances are of various kinds. In some places paddy winnows are used, in others a sort of bamboo winnow with a long handle is used. I have also seen caterpillars being swept by brooms into baskets and ordinary bamboo umbrellas used as bags to collect very young green caterpillars (Plate V, fig. 3). In one place in the Coimbatore District, where paddy seedlings were badly infested with surface grasshoppers of sorts, I found that the farmers used to drive the hoppers to one corner of the plot and beat them to death by means of palmyra leaves, their long stalks being used as handle. Cotton clothes used as upper clothes or headgear by the ryots are also improvised many a time to serve as sweeping bags and worked by two or more men.

Smoking and burning. In parts along the Malabar Coast, a system of creating smoke to drive away the rice-bug is found. The same method is adopted in other places to drive away blister beetles which damage cereals in flower.

The nests of troublesome wasps and bees are also often scorched by a burning torch, generally at night.

Other mechanical methods. To check the rice-case worm in paddy fields, it is a custom chiefly in parts of North Malabar to drag a thorny tree branch across the infested field, which makes the small cases of the worms drop down into the water. This is also said to be practised in the North Arcot District for leaf caterpillars like *Melanitis*, etc.

The covering with muslin or paper bags of ripening fruits of good varieties of pomegranates, mangoes, etc., is a practice in many gardens all over the country, and this certainly has some deterrent

effect upon fruit-borers like borer caterpillars and fruit flies (Plate V, fig. 4).

The use of ant pans in houses to keep away ants from sugar-jars, meat-safes, dairy products, etc., is quite an old custom, as may be seen from the crude granite ant pans used by silk farmers in Mysore, to protect their *mejas* containing silkworm trays (Plate VI, figs. 1 and 3).

The hooked wire is commonly used in parts of Tinnevelly to extract the rhinoceros beetle from coconut shoots (Plate VI, fig. 2).

A very interesting and intelligent method of catching winged termites is in vogue in parts of the Coimbatore District. It is, of course, done not with the idea of destroying the pest, but with the purpose of collecting them in numbers for edible purposes. It is probably not very widely known that some of the low caste cultivators regard the winged termite as a delicacy ; during certain seasons these are sold in bazaars of different towns. I have also heard that among some castes this substance forms one of the important articles of dowry for a bride ! Though resorted to for edible purposes, it must be admitted that this method checks the multiplication of this undesirable insect to some extent. The procedure is as follows :— Just before the usual season when these winged termites emerge, and which the professional catcher knows, a shallow pit is made close to a termite mound and this is filled with water ; this pond is enclosed on three sides by a sort of fencing, the side adjacent to the mound being kept open. A small lamp is lighted and placed at the edge of the pond. After all this paraphernalia is arranged, the catcher sprinkles some water over the termite mound and in a few minutes swarms of winged termites emerge. These naturally hover about the light and drop into the artificial pond, when they are collected by the operator.

In the Ghât regions along the Western Ghâts, and in the Nilgiris and Mysore, it is a pretty common sight to see the bulls of hill carts having suspended from their neck a big brush-like tuft of wool generally black in colour. I have tried to get the meaning of this extra ornament from cart-drivers, but have been told that they are

Fig. 1. A common method of storing ghi, sugar, etc., to prevent ants (the jar kept on a tray full of water).

Fig. 2. Hooked iron rod used for catching the Rhinoceros beetle.

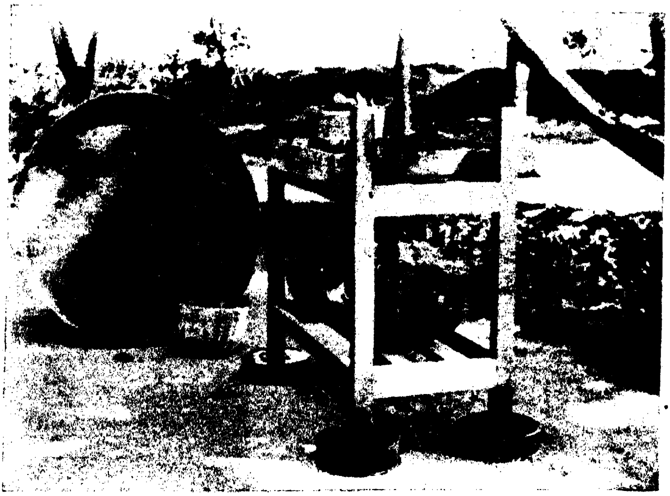

Fig 3. A silkworm shelf put on ant pans.

charms to protect the bulls from diseases. Whatever it is, I find from what I have observed that this tuft of wool keeps away to a considerable extent the biting flies that worry cattle in these hill tracts. Any one travelling in these tracts will notice the havoc done by these flies to cattle, and I am led to think that this tuft of wool is an effective preventive against fly pests.

IV. Medicinal methods.

We might now examine some of these methods which more or less correspond to what entomologists call insecticidal methods.

The commonest practice in vegetable gardens against insect pests of all kinds, no matter what their habits are, is the use of ashes. It will be found used for brinjal fruit and stem borer, *lablab* aphis, cucumber fruit fly, brinjal *epilachna* and many a common vegetable pest.

Once in a village in the Salem District, I saw ordinary white-washing lime being splashed on *lablab* vines against plant-lice.

An improvement in the mechanical method of smoking is found in the following two cases where some extra effect is attempted to be produced by smoking special materials. In the Adoni Taluk, the smoke is produced by burning hides and hoofs of cattle to drive away blister beetles attacking dry crops; in the Dharmapuri Taluk of the Salem District, on the other hand, there is the curious system of burning pig's fat to fumigate a field infected with rice Hispa. There is no doubt that some temporary relief is got by creating smoke, but this latter system of using pig's fat does not show any appreciable effect on the rice Hispa. Speaking of the method of smoking, many of us are, I believe, aware of the burning of frankincense and resinous gums in houses to keep away mosquitoes; but I don't know whether burning and creating smoke with the dung of elephants and horses for mosquitoes is so very widely prevalent. I have seen this in parts of Malabar, Anantapur and Cochin.

Banding with tar of posts and trees against termites, and the use of kerosine against ant nests in buildings, are methods too well known to demand any special remark.

Climbers, when they go up trees like mango infested with the troublesome red ant (*Ocophylla*), often carry with them pouches containing ashes which they splash against trains of ants on the tree branches.

I have seen in some parts along the West Coast that fermenting starchy liquids are exposed in coconut gardens and this is found to attract chafer beetles of all sorts, including the coconut rhinoceros beetle.

It is reported that the use of the powdered cake of the fruit of the Maravitti tree (*Hydnocarpus wrightiana*) checks this coconut beetle and is said to be used in parts of Travancore.

Apart from the manurial value of several oil-cakes applied by farmers to growing crops, such as *nim* (*Melia*), castor, groundnut, some of these possess some insecticidal value of their own, though how far the farmer realizes it is a doubtful point.

In many interior villages different kinds of vegetable drugs are being used in various ways in the belief that they check pests; though many of these are of doubtful value, there are some which show promise of efficacy and which are therefore worth trial at the hands of scientific men.

In different parts of the country stored products, especially grains, are preserved in bins together with the leaves of *nim* (*Melia*) or *nochi* (*Vitex nojinda*) plants; the latter I have seen in parts of South Arcot and Tanjore and the former is, I hear, used to preserve horse-grams, etc., in parts of the Kurnool District. For my own part I doubt whether these have any insecticidal value in keeping away store pests. In some villages along the Mysore uplands, such as Kollegal, grains like *ragi* (*Eleusine coracana*) are stored in underground pits and these keep quite free from pests.

I have recently come to know of a very interesting method of preserving stored products in parts of Mysore, which is by keeping a small quantity of pure mercury in the same bin, and it is said to be very effective.

Speaking of the preservation of stored grains, etc., in general, the method in which store-sheds or granaries are built in different places appears to be more or less satisfactory. The bigger granaries

PLATE

Fig. 1. Grain storing basket. The bamboo matting used in some places, not sufficiently insect proof.

Fig. 2. Grain storing bin made of three earthen cylinders (detachable) with a lid properly plastered at the top; pretty effective in keeping off insects.

are often built with stone pavement, higher up the ground level, and in most cases are as insect and damp-proof as possible. I have seen this to be the case in many villages in the Circars. In the South Arcot and the adjacent districts cheap insect-proof seed bins are found to be used. These are made of earth or bamboo matting, and when properly covered and plastered with cowdung, as is usually the case, the seeds or grains remain quite healthy and more or less free from vermin (Plate VII).

V. Other methods.

A very curious method of driving insect pests has come to my knowledge very recently. It seems that the following method is adopted in the Adoni Taluk of Bellary District to drive blister beetles. One live beetle is caught and smeared with or dipped in a mixture made up of asafœtida, cow-dung, lemon-juice, etc., and is then let loose among the companions, and it is believed that all the beetles are driven away from the field where this dipped beetle is liberated ! This method more or less approaches the modern method of spreading infection with fungi, bacteria, etc., to drive insects.

The use of natural enemies against insect pests is, of course, still in its infancy even in many advanced countries ; we, however, see such an idea in the practice of letting loose ducks into fields infested with swarming caterpillars or grasshoppers—a practice that is noted in parts of the Chingleput District ; the results appear very encouraging.

The above are some of the various indigenous practices I have been able to note, and it is quite possible that many others exist which have escaped my notice. Therefore I must admit that this paper does not exhaust all the local practices found in different parts of the country.

From an examination of the various practices described above, one can hardly doubt that, in spite of the fact that many of them are empirical and devised on imperfect knowledge of the insects and their habits, some at least of the many local methods noted have some practical value and must, therefore, form the nuclei from

which a good many of our modern scientific methods have to develop. This is the case, I believe, in almost every country, especially in those where agriculture is the chief occupation of the people. To confirm this belief, we often find in old publications references to several old ways of dealing with insect pests in western countries. There is a humorous household English couplet suggesting a prescription to check fleas, which runs thus :—

> "When wormwood hath seed, get a handful of twaine,
> To save against March to make flea refrain ;
> Where chamber is swept and wormwood is strewn
> No flea for his life dare abide to be known."

We also read of other commonsense methods adopted in the western countries, *viz.*, baits for wire worms in potato fields, poisoned baits for caterpillars, etc., etc.

In every country, therefore, there must have existed such beginnings, and all later practices form the result of years of scientific study and experience—not only in trying old remedies to test the results, but applying them in ways suited to the habits of different insects after a thorough study of the life of each insect concerned. In India the evolution of the modern scientific methods must and can progress only step by step and it will be far from perfect for many years to come. From fatalism and faith cure to crude measures, and from the latter to intelligent and effective methods, is a gradual progress which has to be effected with a sound ground-work of agricultural education, so that the future Indian ryot will be able to connect intelligently these methods with the habits of different pests and then be in a position to develop or discard the practices of past generations. At the present moment—which can be described to some extent as a transition period—what many of our farmers unfortunately forget is (of course I only refer to the illiterate and ignorant majority) this very sequence of events with regard to the development of control measures and the main fact that all methods suggested by the economic entomologist of modern days have been the result of trials with the accumulated experience of past generations, and that they are devised solely on a commonsense basis without anything superhuman or mysterious underlying them. They

are therefore tempted very often to laugh at the entomologist and blame him for not finding magical and cure-all panaceas for checking all sorts of pests at one stroke. I cannot help adding that even among the educated classes—most of whom are not farmers—this sort of impression prevails in some places. Nor should the modern entomologist be blind to the fact that in some of the crude local practices lurk the germs of many a future successful remedy; he too should therefore be very careful in condemning any such methods before he gives them his best attention.

I believe, however, that time is not far off when, with the co-operation of the scientific entomologist with his insight into the life-history and habits of insects on one side, and the experienced and intelligent Indian cultivator with the local experience of several generations on the other, this suspicious way of looking at each other will vanish to the satisfaction of both the parties and, at the same time, add to the material welfare of the country. The object of this paper is to place before you these unconnected points and invite remarks on this subject from observers resident in other parts of India, and, if possible, to find out the relations between the local practices in Madras and in the other provinces.

CROSS-FERTILIZATION AND STERILITY IN COTTON.

BY

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THE cottons growing under the conditions of the Bombay Karnatak are mostly self-fertilized, but the incidence of natural crossing is by no means insignificant. The principal varieties, *viz.*, Kumpta and Dharwar-American, flower from November to April. Other cottons similarly cultivated follow almost the same course. The flowers in general open in the morning, but the exact time varies according to climate and variety. In cold weather the opening is late, at about mid-day, and in hot weather it is early, being complete before 9 A.M. On the same day the American varieties open their flowers earlier than most of the Indian cottons. The white-flowered *Neglectum* varieties are very late in this respect. They do not open their flowers at all in the cold months of December and January. But as the temperature advances in February and March, the opening takes place at about 12 noon, three or four hours later than other cottons. In any case the anthers burst immediately after the unfolding of the petals. The stigma is receptive at this stage, or at any rate the pollen grains falling on it get a better start in their race than those that reach it later on. The entire surface of the style that projects beyond the staminal column is stigmatic; and this has been proved by cutting the stigma and fertilizing it only at the base. Again, in the majority of flowers the filaments of the upper anthers are sufficiently long to touch the base of the stigma.

All these conditions are quite favourable for self-fertilization. The anthers are in contact with the stigma and they shed their pollen as soon as the flower opens. But, on the other hand, we have in most cottons a very attractive corolla. The quantity of honey and pollen in the flower is profuse, and invites the insects that roam in search of them. All these favour natural crossing. We have thus one set of conditions favouring self-fertilization, and another set favouring cross-fertilization ; but the former occur as a rule and the latter as an exception in all varieties of Indian cottons under observation at Dharwar.

The amount of natural cross-fertilization taking place in cottons varies probably with different varieties. The climatic conditions and the number of insects also play an important part in the matter. It is, therefore, impossible to have constancy in the opinion of different observers on the subject. American[1] opinion is, in general, in favour of high amount of natural crossing under ordinary conditions. In India the problem is not fully studied. Gammie [2] believed that Indian cottons were normally self-fertilized. Other workers on cotton do not seem to have given very serious attention to the question. In Bombay, and probably in other provinces as well, no notice of natural crossing was taken for a long period, and all selection and breeding work was done without any provision of guarantees for self-fertilization. Extra-prolific plants were now and then observed in the field and selected as progenitors of new and valuable races. These, however, disappointed their discoverers by throwing out a number of useless forms ; and still cotton was considered to be a self-fertilized plant. In 1910, Mitafifi (Egyptian) and Cambodia cottons were grown under irrigation at Gokak in adjoining plots. The Mitafifi variety almost failed but the small quantity of seed produced was preserved and sown in the following year. This gave about two hundred plants,

[1] Cook. *U. S. Dept. of Agri., Bur. of Plant Ind. Bull.* No. 147.

Allard. *American Breeders' Magazine*, I, 1910.

[2] Gammie. "The Indian Cottons." *Mem. Dept. Agri. India, Bot. Ser.*, Vol. II, No. 2, 1907.

out of which twenty-four individuals were remarkable for their vigour, prolificness, and quality of cotton. Of these, twelve were selected but none was found to be true to its parent in any character. The appearance of white flowers revealed their hybrid origin. Similar observations were made in other cottons, but the experimental proof of the incidence and extent of natural crossing began to be collected in the Bombay Karnatak from the year 1914. The following methods were employed for the purpose :—

(1) Opening the buds artificially with as little injury to the petals as possible, and leaving them after emasculation to insects to fertilize.

(2) Growing side by side two pure strains of cotton, one with a long leaf and the other with a short one. In this case, the seeds of the short-leaved type were sown in the following year and the amount of natural crossing determined by the number of the long-leaved individuals. It was thus found out that the percentage of natural crossing was 0·5 per cent. according to the first method and 6 per cent. according to the second. The smaller amount in the former case may be accounted for by the unattractive appearance of the petals which were more or less injured while opening them artificially. But there is no doubt about natural crossing taking place in cottons growing at Dharwar, and, in view of the vitiating influence of even the smallest quantity in all our breeding and selection work, to ignore it is fatal in the case of cottons. This being the case, it was decided to prevent natural crossing in cotton-breeding plots by protecting the flowers so as not to allow the access of insects to them. This was done for some time by enclosing the buds in paper bags, but the difficulty of handling a large number of plants in this way led to the invention of a very simple and effective method of putting small iron rings on to the buds.

A large number of plants are thus self-fertilized every year, and this has greatly helped us in producing superior strains and in maintaining them pure. But self-fertilization in this manner, though valuable and indispensable, is believed to induce sterility when continued

for a few years. The observations of Leake and Ram Prasad[1] indicate that there is diminution in fertility in the case of plants raised from self-fertilized flowers, and this diminution is marked in some cases as early as the second generation. If this is valid for all cottons and in all climates, we are really confronted with a problem of a very serious nature. It was for this reason that observations were made at Dharwar on the local variety, *viz.*, Kumpta, with the following results :—Instances of sterility are found in the crop of ordinary Kumpta which is allowed to cross freely in the field. The sterility is of three kinds—(1) affecting all the floral parts except the calyx, (2) affecting the anthers, and (3) interfering with the development of the ovules in the ovary.

In the first kind, the bracteole and calyx are produced on the plant, but the petals, anthers and the style are altogether suppressed. This condition is invariably correlated with a kind of malformation of the leaves which grow greatly reduced in their size and variously curled. But their sterility associated with a general malformation of the plant has obviously no connection with the sterility induced by self-fertilization, and is in the nature of a diseased condition of the plant—a diseased condition the cause of which is not yet known.

In the second form of sterility, the staminal column bears a number of anthers which contain the pollen grains. But all anthers are not fertile, some are empty sacks containing no pollen. These are generally small and shrivelled and of a greyish colour. Thus, in the second kind of sterility the formation of pollen is interfered with on account of the morbid condition of anthers in the flower. In Kumpta cotton such infertile anthers are not uncommon. They are found in about 75 per cent. of flowers. No case of complete sterility in which all the anthers are infertile has, however, been met with, although thousands of flowers were examined specially for the purpose. The number of anthers on the staminal column is about seventy, and in the worst case observed the number of infertile anthers was not more than thirty. The following statement shows

[1] *Mem. Dept. Agri. India, Bot. Ser.*, Vol. IV, No. 3.

the extent of sterility as observed in 500 Kumpta cotton flowers taken at random :—

Number of sterile anthers in the flowers	Number of flowers	Percentage of sterile anthers
0	128	0
1–5	112	7·1
6–10	81	14·3
11–15	93	21·4
16–20	45	28·6
21–25	20	35·7
26–30	21	42·8

We thus see that the local cotton of Dharwar produces infertile anthers even under normal conditions. The same is the case with all cottons growing at Dharwar. Even the American varieties are no exception to this. The ovules, as already stated, are mostly fertilized from their own pollen, and we therefore do not know to what extent this kind of sterility is due to continued self-fertilization. But at any rate if it is partly or entirely the result of self-fertilization, the progeny of individual plants continuously self-fertilized for a number of generations must show a greater degree of sterility than others, and we have for this purpose one such individual continuously propagated for the past six years from the seed of artifically self-fertilized flowers. The amount of sterility in the seventh generation of the above plant is shown below :—

Number of sterile anthers in the flower	Number of flowers	Percentage of sterile anthers
0	111	0
1–5	189	7·1
6–10	132	14·3
11–15	8	21·4
16–20	49	28·6
21–25	11	35·7
26–30	0	42·8
31–35	0	50·0

By comparing this table with the previous one for Kumpta cotton, it will be evident that sterility of this kind has not increased, but on the contrary the percentage of flowers having more than ten

sterile anthers is markedly less in the progeny of the continuously self-fertilized plant. There is another pure strain of white-flowered *Neglectum* cotton originally brought from Sholapur. In this strain the flowers are clistogamic during the cold months of December and January. During the hot months of February and March, the buds open, but late. The anthers, however, burst before the opening of the petals, so that self-fertilization is sure even when the flowers open. The plants of this strain, therefore, are almost entirely fertilized with their own pollen, and it is for this reason that the progeny was found very uniform even in the first generation. Nevertheless, the flowers are duly protected as in other varieties and still there is no marked degree of sterility, as compared with Kumpta in the sixth generation, as seen from the following table :—

Number of sterile anthers in the flower	Number of flowers
0	120
1–5	163
6–10	97
11–15	53
16–20	18
21–25	11
26–30	18
31–35	22

In both these strains the vigour and prolificness are not injuriously affected to any extent. On the contrary, the *Neglectum* type shows marked improvement in these characters.

In these cottons complete sterility of the anthers was not observed. The stigma received during the whole of the flowering period sufficient pollen, but even then all the flowers formed did not develop into bolls. The shedding of young bolls is a thing which is very common in all cottons growing at Dharwar. The varieties which are never artificially self-fertilized are not immune. The following statement shows the number of flowers opened during each month of the flowering period and the amount of boll shedding on

ten Kumpta plants grown from seed always produced under normal conditions :—

Plant number	December			January			February			March		
	No. of flowers opened	No. of bolls formed	Percentage of shedding	No. of flowers opened	No. of bolls formed	Percentage of shedding	No. of flowers opened	No. of bolls formed	Percentage of shedding	No. of flowers opened	No. of bolls formed	Percentage of shedding
1 ..	3	0	100	18	16	11	96	20	79	0	0	0
2 ..	4	3	25	37	20	46	37	1	97	0	0	0
3 ..	1	1	0	28	13	53	60	10	83	0	0	0
4 ..	2	1	50	22	12	45	52	18	65	0	0	0
5 ..	0	0	0	17	14	18	32	7	78	0	0	0
6 ..	0	0	0	28	19	32	37	3	94	0	0	0
7 ..	0	0	0	31	18	42	79	12	84	0	0	0
8 ..	1	1	0	21	15	29	40	10	75	2	0	100
9 ..	1	1	0	25	17	32	38	10	73	0	0	0
10 ..	7	2	71	23	16	30	50	14	72	0	0	0
TOTAL ..	19	9	53	250	160	36	521	105	79	2	0	100

From this it is evident that on the same plants the early flowers are more successful than the late ones. The cause of shedding is not definitely known. Moisture and temperature exert probably a great influence. A crowded condition of plants in the field also plays an important part in this respect. Leake[1] finds that the percentages of bolls to flowers is small on continuously self-fertilized types and he, therefore, thinks that shedding is induced by self-fertilization. The observations made at Dharwar, however, do not show that continued self-fertilization has any such influence, as evidenced from the following statement :—

Name of cotton	Description	Number of flowers produced in the season on 135 plants	Number of bolls formed	Percentage of shedding
Kumpta	Never selfed	4,202	1,580	62·3
Dharwar No. 1 (a strain of Kumpta)	Continuously selfed for 6 years ..	3,858	1,897	50·8

[1] *Mem. Dept. Agri. India, Bot. Ser.*, Vol. IV, No. 3.

Continued selfing thus does not seem to cause excessive shedding of the bolls by increasing the sterility of the anthers, or in any other way.

The third form of sterility which interferes with the fertilization and development of some of the ovules in the ovary is also, like the second, common in many cottons. The average number of ovules in the ovary is nineteen in the case of Kumpta cotton, but the average number of seeds in the ripe boll is eighteen. Thus one ovule per boll on an average fails to grow into seed. This was first thought to be due to something wrong in the pollen. Twenty flowers were therefore pollinated with the pollen of sister plants using much larger quantity than necessary. The ovules were then examined on the third day when it was quite possible to detect the unfertilized or abortive ones by the absence of hairs on them. Thus it was found that, out of 371 ovules, fifteen remained without making any progress. Most of these were the top or bottom ones. The sterile condition of the ovules, therefore, seems to be due to their unfavourable position in the cell. The number of abortive ovules in the pure strain continuously self-fertilized is almost the same, there being no increase.

In conclusion, therefore, it may be said that there are three forms of sterility in Kumpta and other cottons growing at Dharwar, and that their amount has not been found to increase in pure strains subject to continued self-fertilization for a number of generations.

SOME OBSERVATIONS ON THE INFLORESCENCE AND FLOWERS OF THE GRAPE.

BY

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The inflorescence (flowering shoot) of the grape consists of the common peduncle (or stalk), of the sub-peduncle and of the flower-tendril. Sometimes the flower-tendril may be absent. The sub-peduncle consists of a main axis on which secondary axes bearing flowers are borne. This secondary axis also bears the tertiary axes which in turn bear flowers. The inflorescence is thus a compact panicle.

Transition forms of the inflorescence. All stages between inflorescence and tendrils are noticed. Plate VIII, fig. 1, shows all intermediate stages from the normal inflorescence to a tendril. Plate VIII, fig. 2, shows the homologous modified inflorescences bearing fruits. In Plate VIII, fig. 1 (III), the sub-peduncle has assumed the form of a tendril with only few flower-buds. Sometimes the flower-tendril is replaced by a normal sub-peduncle bearing flowers and fruits as in Plate VIII, fig. 2 (III). In the variety Campbell's Early (Tree No. 38, in the Ganeshkhind Botanical Garden), it was peculiar to note that the flower-tendril had branched at the top and both the bifurcated branches had a few flower-buds. Plate IX, fig. 2, shows an extreme case of a tertiary axis becoming curved and assuming the form of a tendril. When the sub-peduncles and the flower-tendrils bear the same number of flower-buds, they generally drop off, and the whole then looks like a

Fig. 1. Transition stages of the inflorescence into a tendril (Phakadi).
I, Sub-peduncle is a normal inflorescence;
II, ,, curved, showing its irritability;
III, ,, much curved with few flower-buds
IV, ,, becoming a tendril.

Fig. 2. Homologous nature of the tendril to modified inflorescence (Phakadi).
I, A normal flower tendril; II, A flower tendril with few fruits; III, Tendril looking like a normal sub-peduncle.

Fig. 1. Two inflorescences appearing side by side (Phakadi).

Fig. 3. Three fruit branches on one shoot (Campbell's Early).

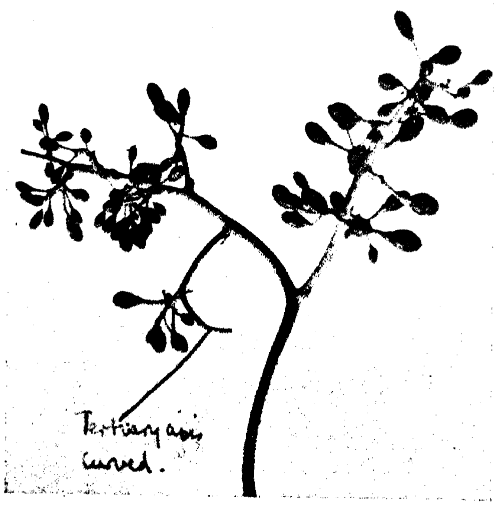


Fig. 2. One of the tertiary axes curved and becoming a tendril with no flower-buds (Phakadi).

normal tendril. Generally, the formation of the sub-peduncle into a tendril means the development of a few flower-buds and the consequent elongation of the axis.

Their position. As a rule, the inflorescences appear at the 5th and 6th pair of leaves and are found on shoots developed on spurs left after the October or April pruning. They may, however, depart from this rule. The following are some examples :—

TABLE I.

Plant No.	Name of the variety	Position of the inflorescences
328	Pandhari-Sahebi	3rd and 6th pair of leaves.
319	Ditto	4th and 5th pairs
312	Phakadi	7th pair.
131	Bhokri	4th and 6th pairs.
—	Neelam	3rd, 4th, 5th and 6th pairs successively.

If there be another shoot developing at the axil of the 5th pair of leaves, then the inflorescence is borne at the first pair of leaves of the new shoot.

Not more than two fruit bunches are found in the bearing shoot. In Campbell's Early a shoot had three fruit-bunches (Plate IX, fig. 3). In Neelam a shoot had four fruit bunches. Plate IX, fig. 1, shows an extreme type where two inflorescences have been found appearing side by side.

Their appearance. The inflorescences do not appear on every shoot developed on the spurs. Quite a large number of the shoots go without any inflorescence. The presence or absence of the inflorescence on these shoots may be due to a number of causes, chief amongst which are the varietal characters, the method of

training or other treatment given and probably the seasonal conditions of the year. The following tabular statement gives some details :—

TABLE II.

Variety			Method of training	Number of vegetative shoots	Number of shoots with 1 inflorescence	Number of shoots with 2 inflorescences
Bhokri	134	..	Single-stake	11	14	5
Do.	179	..	Do.	18	13	9
Phakadi	300	..	Do.	27	10	0
Do.	298	..	Do.	37	14	0
Kandhari	570	..	Do.	29	3	0
Do.	568	..	Do.	37	5	0
Black Prince	17	..	Bowers	23	30	19
Do.	18	..	Do.	34	31	17
Italian	84	..	Single-stake	16	0	0
Do.	83	..	Do.	19	1	0

From the above it will be clear that Black Prince has few non-bearing shoots and that Italian has practically no bearing shoots.

TABLE III.

Variety, Pandhari-Sahebi.

Nature of the operation	Number of branches operated	Number of vegetative growths	Number of shoots with one inflorescence	Number of shoots with two inflorescences	Percentage of shoots to branches operated	Percentage of bearing inflorescenced shoots to shoots formed
Coiled	22	35	31	10	345·4	53·9
Ringed	17	6	10	0	94·1	62·5
Extended	31	46	67	19	425·8	65·1

From the above it will be seen that branches when extended bear quite a large number of bearing shoots.

Colour of the inflorescence. The peduncle and the sub-peduncle in some varieties are coloured. In Bhokri and a variety known by the name of Patawardhanii, they are coloured with a reddish tinge. This seems to be correlated with the colour of the young growing shoot and veins and petioles of leaves. This colour is almost absent in Phakadi and Sahebi.

The flower. During the month of November, when one visits the grape plantation of the Ganeshkhind Botanical Garden, one sees quite a large number of plants coming into bloom. This period of coming into flowers is also observed in the month of May after the April pruning. In countries where the grape comes into flush only once a year, it produces flowers only once, *viz.*, in the month of May or June. The period of flowering, however, can to a certain extent be regulated by early or late pruning. In Ahmednagar, where pruning commences early, *viz.*, in September, the grape comes into flower in October. In the Ganeshkhind Botanical Garden, two grape plants were pruned—one on 27th December, 1918, and the other on 9th January, 1919, respectively. These bore flowers on 23rd January, and in the first week of February 1919. Similarly, two Black Prince plants were pruned on 5th September, 1919. These bore flowers in the first week of October.

The grape flower is minute and regular. The calyx is a narrow rim at the base of the flower; the corolla has five united greenish petals. The stamens are generally five but variations in their number may often appear. Four to six stamens have often been noticed. In foreign literature imperfect flowers, *viz.*, with rudimentary stamens or ovaries, have been mentioned. In such cases the stamens are generally curved but such flowers have not so far been observed by the writer. This may be the result of good and bearing varieties being introduced in the Ganeshkhind Botanical Garden.

The flower is so constructed that while opening self-pollination is the general rule. At this stage the petals come out in the form of a cap with the stamens and pistil exposed. Flies (not yet identified) have also been noticed to visit the flowers more for the sake of honey than for pollination (as no pollen grains were so far noticed on their

body or legs). These flies are especially found in the Black Prince variety and are characterized by distinct smell. The flowers generally begin to open in the Ganeshkhind Botanical Garden from 9 a.m. or a little later if the atmosphere is cloudy, the largest number of flowers opening between 9 and 11 a.m. They commence to open after a period varying from 24 to 40 days after pruning. Unlike the mango, the grape does not take a long time to finish its flowering period. An inflorescence containing about 350 flowers finishes off its work of flower opening in the course of 4 or 5 days. The varieties Black Prince and Campbell's Early have been noticed to finish off flowering earlier than the other varieties, Phakadi and Sahebi being found to close their flowering period late in the season.

Selected Articles

THE GROWTH OF THE SUGARCANE.*

BY

C. A. BARBER, C.I.E., Sc.D., F.L.S.

VI.

THE early stages of growth in a cane field have, as is natural, always received a great deal of attention from planters. The writer well remembers the first time he planted a field of sugarcane and the occasional panic which seized him before the full set of young cane shoots appeared above the ground. He had, greatly daring, attempted to introduce the West Indian practice into one of the great deltas of Peninsular India.

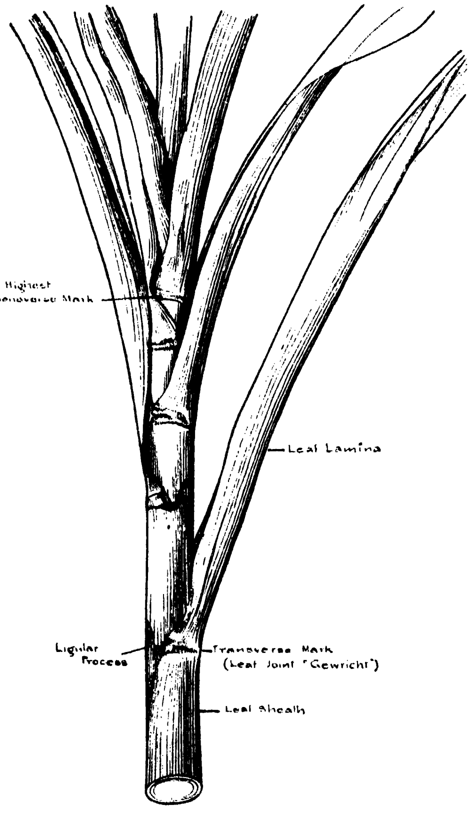
Everyone is aware that the plants may become quite tall before any cane is formed, and that the leaves are at first very far ahead of the canes in their growth. While the leaves are rapidly succeeding one another and pushing up into the air, they are at the same time gradually becoming broader, the first leaves being very narrow, but the later ones soon reaching a respectable width, and this is to be accounted for by what is going on in the stem below. From the slender, pencil-like joint which starts from the bud on the set, a cane has to be built up, which will support the whole aerial part of the plant, and it is obviously necessary that the stem should emerge from the ground with its full thickness and grow up thereafter pillar-like in form. As each individual joint is more or less of uniform thickness throughout its length, a greater size of cane can only be obtained by each joint becoming thicker than its predecessor. A vertical section through the stem at the base of a young plant will thus have

* Reprinted from *The International Sugar Journal*, June 1920.

the form of an inverted cone made up of a series of disc-like segments, the lower ones narrow, the upper ones broader. Every joint bears one leaf and, as a great number of the latter are wanted at the earliest possible moment to provide food to build up the tissues of the plant, a large number of joints are found in this basal cone. The leaves have a broad insertion on the joints, in fact, at a later period, more than fully encircle it, so that as the joints gradually become thicker, the leaves belonging to them become broader. This increase in width of successive leaves is rather slow at first, but there is nothing to hinder their growth in length, and they may be 4 or 5 ft. long before the stem has reached its full thickness and emerged above the ground. Any attempts to measure the growth of the cane, depending on the height of the plants in the field, are therefore misleading, and the real difficulty of studying this growth lies in the fact that the young joints and their attached organs are, throughout their period of increase, deeply hidden away within a mass of protecting older leaves, which must be removed before they can be observed. As such removal will seriously interfere with normal growth, if it does not actually dry up the tender inner parts, the matter becomes a good deal complicated. The way in which these difficulties have been overcome and a connected study of the growth, from the commencement, of the stem and leaves of the cane plant has been rendered possible, forms the subject of the present paper.

The mature cane plant above ground consists of a series of joints, one above another, each of which bears a leaf with a bud in its axil. The leaf consists of two parts; a broad, green, flat lamina or blade, and a thicker, stiff, lower portion which fixes it to the stem, the leaf sheath. These two parts of the leaf are separated by a kind of hinge, the leaf joint, which makes it possible for the blade and sheath to be placed at an angle with one another, so that they do not lie in the same line whether straight or curved. At the point of junction of blade and sheath, there is a more or less distinct coloured band which we may call the "transverse mark," and this in younger leaves serves as a useful guide as to where the blade ends and the sheath begins. These parts are shown in the accompanying drawing.

We have to study the growth in length of these three parts, the joint, sheath and blade, and we shall find that they differ a good deal in time and degree. The time-honoured rough and ready method of measuring the growth of the cane was to fix a stake firmly in the ground and tick-off on it the postion of the uppermost clean joint which might be called mature. If marks are made on the stake at intervals of, say, a month or a fortnight, the distance between



two successive ones will give the growth of the cane during that period. But this method is liable to the objection that it is difficult to decide just what joint is mature, for the different varieties vary a good deal in the ease with which they throw their old leaves, and if these are gently removed, the personal factor of the observer plays a rather too prominent part in the measurements to inspire confidence.

In the absence of direct observation of the growing parts, the first problem is to determine whether there is any definite external

point on the plant, which bears a fixed relation to the hidden apex of the stem. Fortunately for our study, there is such a point, and by its use a good deal of information has been obtained. In 1904 Kamerling[1], in Java, pointed out that the highest, just visible transverse mark could be used as a fairly safe guide to the position of the parts within. And, as his work lies at the foundation of all subsequent studies on the growth in length of the parts of the cane, it will be necessary to consider it carefully, without going into unnecessary detail, for the paper is in Dutch and rather long and complicated. He was able to show that there is a definite sequence in the growth in length of the blade, sheath and joint. First of all the leaf shoots up, then the sheath elongates and, lastly, the joint belonging to them increases in length. Kamerling further discovered that these three periods are sharply separated from one another : the sheath does not begin to grow in length, until the blade has stopped : the joint again only commences to lengthen when the sheath has attained to its full size. This sequence of growth has a close connexion with he proper nourishment of the plant. The leaf is matured as early as possible, both to prevent evaporation and the wilting of its tender tissues and to give as large a surface as possible for feeding on the atmosphere. It shoots straight up into the air. When it has completed its growth, the sheath, acting as its base, with all its cells ready formed and merely needing extension, in a very short time pushes the leaf further into the air, thus separating it from its neighbours in the bunch, and, also, because of the leaf joint throwing it outwards away from the mass in the centre, so that there may be freer circulation of air around the blade. The stem, when it in its turn elongates, completes this important operation, the weight of the leaf causing it to fall more and more from the vertical position, so as to give more room for the succeeding leaves.

The way in which Kamerling was able to fix upon the highest transverse mark as indicating the position of the hidden stem apex was as follows : He found by measurement that the moment of its

[1] Kamerling, J. De lengtegroei van het riet. *Archief voor de Java-suikerindustrie*, 1904, p. 997.

appearance to view practically coincided with the completion of the growth in length of the sheath. When the sheath had reached its full length and the transverse mark appeared, the joint to which it was attached was about one-third of an inch in length, and the joints above it right to the apex were still shorter as well as narrower. None of these joints had as yet commenced to grow in length. Any upward movement of the newly emerged transverse mark—and this took place now fairly rapidly—was therefore to be traced to the elongation of the part of the cane below the point of attachment of the sheath. We have thus, in the upmost visible transverse mark, a fixed point of the nature desired. By measuring the height of this mark above the ground, we can, at any time, calculate the length of cane which has attained its full thickness, by deducting the length of the sheath, and, by a series of measurements at different periods, we can form a fairly accurate estimate of the rate of growth in length of the cane.

But there is a proviso in the use of this method of Kamerling's. It assumes that the length of successive matured sheaths is the same all up the stem. If, for instance, a short sheath were succeeded by a long one, the growth of the cane during the interval would be greater than that inferred by the observation of the marks. This point was appreciated by him and he measured the length of all the sheaths in a number of canes. The result of this showed that, during the period of active growth, when the cane had attained its full size, the sheaths rarely differed by more than a quarter of an inch in length, but that at the commencement of growth, and towards the end, the sheaths rapidly became shorter. The method, therefore, cannot be relied on in the early and late stages of the cane's growth. The importance of this proviso is illustrated by a piece of work done recently in India. Taluqdar,[1] in 1915, studied the growth in length of a number of Indian varieties, at the Agricultural Station at Sabour in Bihar. He first of all drove strong iron stakes deep into the ground and marked them at the actual ground level, before this

[1] Taluqdar, J. M. "Notes on the growth of the sugarcane." *Bihar and Orissa Agricultural Journal,* April 1915

was obscured by subsequent tillage operations and earthing-up. From these marks, as fixed points, measurements were taken at intervals to the uppermost transverse marks in order to judge of the rapidity of the growth of the canes in different months. But it has been shown by the writer of this article[1] that, although there is little variation in the sheath length in thick tropical canes during the period of full growth, this is by no means the case with indigenous Indian ones. Differences of over an inch between adjoining sheaths are not uncommon. Further, Taluqdar appears to have taken no note of Kamerling's warning as to the danger of applying the method at the commencement and end of the growing period, but began his measurement at the earliest possible moment. Fortunately for his deductions, the measurements were only taken at comparatively long intervals, so that much of the irregularity of length of leaf sheath was ruled out and the results are of considerable value. The similarity of growth conditions in North India to those in Louisiana was clearly brought out. In both cases the growing period is extremely short, barely exceeding six months, and the growth during that period is very rapid, probably a good deal more so than in most tropical countries where the period ranges somewhere round twelve months and in some cases considerably beyond it. It is obvious that, without this rapid growth in these extra-tropical regions, hardly any crop worth reaping could be grown. In both cases intense heat with great moisture presents ideal conditions for forcing the plants to their greatest activity of growth in length, and in both cases the period is terminated by a decrease in temperature and sometimes of moisture, in which no further growth is possible.

Kamerling touched on many other matters connected with the growth of the joints and leaves, but there is no space to deal with these here, especially as they have been much more accurately studied recently by Kuijper, also in Java. It may be noted, in passing, that the main pieces of work connected with the subject, with which the writer is acquainted, come from Java at comparatively long

[1] **Barber, C. A.** "Studies in Indian Sugarcanes, No. 5." *Memoirs of the Department of Agriculture in India, Botanical Series*, **1919**, p. **159** and **Plate I.**

intervals. Kobus in 1887 to 1893 studied the growth in length of the leaf, and showed that the blade attained its full growth much sooner than the sheath. Kamerling's work was published in 1904, when he laid the foundation of our knowledge of the relative growth of joint, sheath and blade. It was not until 1915 that the next important paper, written by Kuijper,[1] appeared. As might be expected, this paper is written on a different plane to that of the earlier observers, in that it replaces the older methods by a much more up-to-date one. After working over Kamerling's results, the writer extends his observations to a thorough investigation of the whole subject. Kuijper was interested in a disease of the cane shoot, which seemed to depend on the relative growth of the various immature organs while still hidden away in the recesses of the bunch of leaves, and he found that he required much more accurate details than could be obtained by the use of Kamerling's method. In place of measurements of growth of comparatively fully formed organs obtained by inference, he needed actual measurements of the very youngest organs near the vegetative apex. Kamerling had, it is true, also attempted this, and boldly cut away the older tissues and protected the young parts exposed by tin foil, but serious injuries resulted which disturbed the normal growth, and the method was abandoned. Kuijper applied the ingenious plan of piercing the whole apex by strong needles which would leave a series of minute holes, and by unravelling the complex of leaves and joints after an interval, he was able to judge by the displacement of the holes the actual growth in length of the different organs during the time. By making a series of holes one centimetre apart, he was able to build up a scheme of the internal growth of the sugarcane which approached very near completeness. A second longer paper giving further details appeared in 1918,[2] and it will be sufficient for our purposes if the main results of Kuijper's studies are summarized here.

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[1] Kuijper, J. "Degroei van bladschijf, bladscheede en stengel van het suikerriet." *Mededeelingen van het Proefstation voor de Java-suikerindustrie*, 1915, p. 211.

[2] Kuijper, J. "Voortgezette metingen omtrent des lengtegroei van het suikerriet." *Ibid*, 1918, p. 163.

As a convenient convention, he signifies by the figure 1 the parts connected with the uppermost visible transverse mark, namely, its leaf, sheath and joint; older sheaths, namely, those further down the stem, he denotes by 2, 3, 4, etc., while the younger sheaths, which have not yet appeared, he numbers 0, – 1, – 2, etc., upwards. In his first paper, he generally confirms Kamerling's results. The leaf blade is the first organ to be developed and it completes its growth before the sheath commences to elongate, this being in like manner followed by the joint to which it is attached. The blade is already completely developed in – 2, and the sheath commences to elongate there: the sheath is complete in 1 and the elongation of the stem takes place concurrently in 1 to 4. The growth of all these parts is at first basi-petal, afterwards intercalary. That is, the top of the organ is the first to be finished and the region of elongation passes downwards along it; the lowest part next completes its growth and some more increase then takes place in the portion intermediate between the two. This applies equally to blade, sheath and joint.

In the second paper he finds that the period between the first appearance to an outside observer of two successive transverse marks varies, in the kinds of cane examined, from five to seven days. Growth in length of the cane, which is confined to joints 1 to 4, takes about 15 days to complete in this section. The growth in length during the night is considerably greater than during the day, especially in the joints immediately below the arrow. A grand period of growth is observable, as in other plants, in the sugarcane as a whole. Although rain causes some disturbance to this curve of growth, it has not the power of materially altering it. Rainfall, however, strongly influences the daily growth, either by altering the relative daily and nightly increases, or, somewhat later, by increasing the general rapidity. The influence of air moisture on growth was hardly perceptible in any case examined.

The Java work on the growth of the cane was obviously conducted under strictly local conditions, and it is desirable, now that the way has been clearly indicated, that plant physiologists in other countries should take it up. This is perhaps especially the case with India, where there are an entirely different set of canes grown, and

in the Louisiana plantations, where the climatic conditions are so very diverse from those in Java. By following Kuijper's method, exact data may be accumulated on the experiment stations; but by Kamerling's, it is open to any planter to conduct experiments on the different varieties grown, and on the effect of varying treatment of the fields on the growth of the canes. It is a truism that in every crop the work done in any one region must be tested in other places, if the conditions of soil and climate are different, and in no crop are the local circumstances of more importance to growth and yield than in the sugarcane.

BREEDING DAIRY CATTLE FOR MILK PRODUCTION.*

BY

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DURING recent years attention has been repeatedly directed to the importance of increasing the yield of milk from the dairy herds of this country. The Committee on the Production and Distribution of Milk, in their final report,[1] draw attention to the steps which can be taken to reduce the cost of production and increase the profit to the farmer, and the Agricultural Sub-Committee, in dealing with the subject of the improvement of home breeds,[2] laid special stress on the possibility of obtaining better yields by improved breeding methods.

In order that a farmer may discover and dispose of his poorest and unprofitable milkers, it is essential that the practice of milk recording should be adopted, while a careful study of methods of feeding may result in a better yield from the same expenditure on food, but to maintain a herd at a high average yield it is necessary to ensure that the heifers reared to replenish the herd shall milk as well as, or better than, their dams. To attain this result, the utmost care must be given to the selection of the sire and to the choice of cows which are likely to produce heifers of the desired type and qualities.

The owner who wishes to improve his herd by breeding must first decide upon the type of animal he wishes to breed. Where the herd consists of cows of purely dairy type, such as Jerseys, Guernseys,

* Reprinted from *The Jour. of the Min. of Agri.*, Vol. XXVII, No. 7.

1 "Final Report of the Committee on the Production and Distribution of Milk." (Cmd. 428), p.13, par. 51 (2); p.14, par. 59.

2 *Ibid*, p. 29, par. 3.

or Ayrshires, the decision should not be diffcult, but attention will need to be given to differences in type and size. Thus, in Jerseys the rent-paying farmer may well consider whether he should adhere to the Island type or try to develop a larger, hardier type; it may be less refined, but possessing equal or greater powers of milk production.

With cows of the dual-purpose type, the need for a clearly defined aim is even more necessary. As the objects for which the dual-purpose cow is kept are to give a good yield of milk annually (say, 7,000 to 10,000 lb.), to lay on flesh readily on the best parts of the carcass when fattening, and to produce heifer calves which will be satisfactory dairy cows and bull calves which can be reared into good steers, it is easy for the breeder to think so much of one of these objects as to neglect others.

There is considerable divergence of opinion as to whether the dual-purpose ideal is really attainable, *i.e.*, whether it is possible to combine in a family of animals the desired excellence in all directions. It is readily granted that individual cows possess the two qualities of large milk yield and fattening capacity to a high degree, but it is by no means proved that they possess the power of producing both heifers as good as themselves, and steers with the conformation and fattening capacity required in high-class beef animals. The practice of some breeders in selecting one bull from a family more noted for beef than for milk in order to increase the substance of the herd, and, later, selecting a bull from a dam with a high milk record in order to raise the falling milk yield, supports to some extent the point of view that it is almost impossible to breed dual-purpose cows from similar stock with any certainty.

It is sufficient here to point out that efforts to attain a dual-purpose ideal may lessen the chances of success in breeding for milk production, and it is suggested that the farmer, whose main source of income is milk or other dairy products, should concentrate his attention on improving the constitution, the breeding powers and the milk yield of his herd.

The breeder should first make himself familiar with the principles of breeding, and consider their application to his own particular

conditions. More rapid progress is likely to be made when a group of farmers in one district are working for improvement in the same direction and with similar material. Friendly co-operation and competition are invaluable, and in this direction milk recording societies may do much in bringing owners of the same breeds or with the same aims in touch with one another.

PRINCIPLES AND SYSTEMS OF BREEDING.

The first principle to be noted is embodied in the familiar phrase "like begets like," and the second is that the progeny always show a greater or lesser degree of variation from their parents. A tendency has become evident in recent years to modify the first phrase to "like tends to beget like" and to amplify it to "like begets like or the likeness of an ancestor." Observation suggests that the latter is probably more correct. It has been the custom of some writers on breeding to speak of the inheritance by the immediate progeny of characteristics possessed by their parents and the variation of progeny from the characteristics of their parents as antagonistic "forces," but a closer study of the problem has made it clear that, except in very rare cases, variations from the type, colour, etc., of the parents, may be just as truly inherited from some ancestor as are the exact repetitions of features possessed by the parents. Further, variations may be either away from or toward the ideal aimed at. The former are undesirable and disappointing, while the latter constitute an opportunity for progress in the desired direction. The main problem for breeders is how to transmit the maximum inheritance of the desirable qualities possessed by the parents. The *uncertainty* as to the results which will follow from the mating of any two animals, is one of the greatest hindrances to successful breeding.

The application to stock breeding of the discoveries of Mendel and his followers has thrown considerable light on the inheritance of such easily identified characteristics as colour of coat, colour of face, and presence or absence of horns, but little progress has as yet been made with other and more important characteristics, such as high and low milk yield, high and low butter fat content, capacity for

fattening and tendency to leanness. Progress has been hindered by the absence of clean-cut dividing lines and the difficulties of identification, the slow rate of reproduction in cattle, the differentiation of sex and the impossibility of directly assessing the dairy qualities of bulls. These difficulties, however, should be overcome in time, and there are doubtless many present-day breeders, who would be ready to co-operate in the collection of data on single or related points if some lead were given them in this direction. Mendelism may one day enable the dairy farmer to breed heavy-milking stock with the same certainty as the breeder of Aberdeen Angus cattle breeds black and hornless animals.

Systems of breeding.

The systems of breeding adopted are usually described by one or other of the terms crossing, grading, in-breeding, or line-breeding.

Crossing usually describes the mating of animals of distinct breeds, *e.g.*, Shorthorn with Jersey. The first cross between some breeds is often a popular and useful commercial animal, combining to some extent the desirable characteristics of the parents. At the same time, the introduction of the characteristic of another breed must increase the uncertainty as to the qualities which will appear in individual offspring, particularly in the second generation. Crossing, therefore, by increasing the tendency to and possibility of variation, cannot be a successful means of improving a herd. Crossing is sometimes applied to the mating of animals of different types or families within a breed, and the result in this case is similar; the first cross often shows a combination of the qualities of the parents, but in later progeny, the greater tendency to variation increases the uncertainty as to the inherent qualities of the progeny.

The term "grading" is in common use in America, and describes the continued mating of cows of a nondescript type with pure-bred bulls of some breed having the desired qualities. This method has been largely used in the past in building up several of the pure breeds of the present day. The scheme of the Dairy Shorthorn Association for the registration of the progeny of pedigree bulls out of cows of approved type, embodies the principle of grading. This

system offers the surest means of improvement where the owner of a herd of cows of mixed ancestry cannot see his way to dispose of his herd and replace it by cows of a pure breed.

In-breeding is the mating of closely-related animals, *e.g.*, sire and daughter, dam and son, and is the opposite of crossing. When this system is followed, there is great probability of the appearance in the progeny of the characteristics of the parents, and small likelihood of variation from the desired type. It is the surest and speediest of all breeding methods for fixing the characteristics which are desired, and it has been a predominating influence in the building-up of most of our present-day breeds.

In contrast to its power for good, in-breeding, carried on unwisely, may cause disastrous results. Loss of size, constitutional vigour and breeding powers have in some notable cases followed from persistent in-breeding, and at the present day the practice of this system is uncommon.

Line-breeding describes the mating of animals that are more or less distantly related to each other. It might be called a modified form of in-breeding, because it embodies the same principle—that of concentrating and fixing family type and qualities. At the same time, the degree of relationship is not close enough to cause any serious risk of the development of the bad effects of in-breeding. This system is extensively followed in most of the pure breeds, and has given most satisfactory results. Close line-breeding would be exemplified by the use of two sires from the same family, each being mated with the daughters of the other; this method is only practicable where a fairly large herd is kept and the bulls may be retained with safety. The mating of successive bulls from the same family with the progeny of each preceding sire would illustrate more distant line-breeding, and the adoption of this method is within the power of the average dairy farmer.

Pedigree and its uses.

Pedigree provides information on the ancestry of individual animals, and are of incalculable value to all breeders. It is only by a study of pedigrees that a breeder can obtain the information

necessary to enable him to follow a system of line-breeding. The description of a pedigree usually given, however, is incomplete and misleading. It is customary to trace the descent only through the female side, and often an animal is described by a family name, when it traces its ancestry on the female side to some famous cow, although this cow may be only one of four great-grand-dams. The dam and grand-dams of the sire are just as important as the dam and grand-dams of the dam.

It is also most desirable that the statement of pedigree should be supplemented by reliable information as to the dairy qualities of the dams and the dairy prepotency of the sires. In this respect, milk records meet a great need, and the breeder would be helped materially if a uniform method of stating milk yields were adopted.

Definition and measurement of dairy qualities.

Some definition of the desired dairy qualities is first necessary. Five may here be mentioned :—(a) large milk yield ; (b) persistency of milk yield ; (c) high milk fat percentage ; (d) regular breeding powers ; and (e) good constitution.

Of these qualities, (c), (d) and (e) are possessed, often to a high degree, by cows of beef breeds. They are not confined to the dairy breeds, but are included here in addition to the specific dairy qualities of a large and a persistent milk yield, because they are essential in first-class dairy cows of any breed.

It is next desirable to ascertain the extent to which these different qualities are related. Some information on the first four points has been collected through the agency of milk recording societies, and the development of this practice should enable valuable data to be obtained. Milk recording, as carried out in England and Wales, collects information on the quantity and persistence of milk yields (a) and (b), and, where the cows remain in recorded herds, on breeding powers (d). Only in rare instances is information collected on fat percentage (c), and this defect lessens the value of the work of the societies as an aid to the study of the inheritance of dairy qualities and to breeding in general. With regard to constitution (e), it may be inferred that no cow will give high milk yields and

breed annually for, say, five or more years unless she possesses a very sound constitution, but the maintenance of constitutional vigour is closely associated with conditions of rearing, housing, feeding and the risk of incurring infectious or contagious disease. The question of feeding is important, since a heavy milker may break down after a few years, if she has been poorly fed.

With regard to the correlation between the other qualities, the opinion is commonly held that a large milk yield is usually associated with a low percentage of fat, and *vice versâ*, and that heavy milkers are less regular breeders than those giving lower yields. The actual correlation between these and other points can only be arrived at after careful study of a large amount of information, but the breeder is not so much interested in the degree of relationship found in a large number of animals between, say, large milk yield and high fat content, as in the discovery of individual animals which possess *both* these qualities. If it be a general rule that high yields are associated with low fat content, it is the *exceptions to the rule* that form the breeder's opportunity for the improvement of his herd. Such exceptions are fairly numerous.

In this connection it is important to record the conclusion of Professor Wilson,[1] after the study of several thousands of records of Ayrshire cows, that the inheritance of quantity and quality—high yielding capacity and fat percentage—are independent of each other. It should, therefore, be possible to unite in the progeny of selected parents, the two qualities of large yield and high percentage of fat.

INHERITANCE OF DAIRY QUALITIES.

This conclusion leads directly to a consideration of the inheritance of dairy qualities. Can it be said that cows which are found to possess one or more of the qualities referred to pass these on unfailingly to their progeny ? Every breeder knows his own disappointments in this matter. Cows with high records, even when mated with most carefully selected bulls, fail to transmit their qualities to their offspring, while others with moderate records have

[1] *Scientific Proceedings of the Royal Dublin Society*, Vol. XII (N.S.), No. 35, July 1910.

progeny which excel their dams. As illustrations of the uncertainty which is often met with, the following details, taken from the records of the herd of non-pedigree Dairy Shorthorns at the University College Farm, Reading, may be interesting :—

Dam		
Rose (No. 16) 7 L. P.—9125* lb. 45·7 wks. 11 wks.	Rosamond (No. 47) by "A." 5 L. P.—11,397 lb. 50·6 wks. 9·6 wks.	Rock Rose (No. 58) by "C" 3 L. P.—6,058† lb. 36·3 wks. 15 wks.
	Rosabelle (No. 49) by "B." 4 L. P.—7,098 lb. 41·2 wks. 9·8 wks.	
	Rosemary (No. 55) by "C." 2 L. P.—8,003 lb. 42 wks. 9 wks.	
Fillpail (No. 28) 1 L. P.—5,036 lb. 37 wks. 8 wks.	Fillpail (No. 46) by "A." 1 L. P.—1,086 lb. 13 wks.	Fillpail (No. 57) by "C" 3 L. P.—7,792 lb. 40·6 wks. 12·7 wks.
Bell (No. 7) 2 L. P.—8,225 lb. 43 wks. 13 wks.	Bell (No. 41) by "A." 6 L. P.—9,891 lb. 45·8 wks. 15·3 wks.	Belinda I, (No. 50) by "C" 1 L. P.—4,191 lb. 29 wks.
		Belinda II, (No. 61) by "C" 1 L. P.—3,468 lb. 32 wks.
		Bella (No. 67) by "D" 1 L. P.—2,063 lb. 25 wks.

"A" — a pedigree Dairy Shorthorn bull and sire of heavy milking stock (*see* p. 83).
"B" — " " " " " " "
"C" — " " " " the sire of stock giving good yields (*see* p. 84).
"D" — " " " " the sire of stock giving fair yields.

The figures under each cow show the number of lactation periods, the average milk yield, the average number of weeks in milk and the average number of weeks dry.

The progeny of the cow Rose (16), though by three different sires, have been very good dairy animals ; one of them, Rosamond (47) by bull "A" especially so. The daughter of Fillpail (28) by the same bull was a complete failure as a milker (*see* Fillpail (46)), but the daughter of Fillpail (46) by bull "C" is an excellent cow.

Bell (7) was a good cow, and her daughter by bull "A" was even better. The latter's daughters, however, have been disappointments, though two of them were by bull "C," the sire of the good cow Fillpail (57).

* 2 quarters only for 5 lactation periods.
† 3 " " " 2 " "

The system of breeding followed in the herd from which the above details were obtained, partakes more of grading than of any of the other systems described, and is fairly representative of the methods followed by the progressive dairy farmer. The degree of uncertainty as to inheritance of these qualities is probably less in some pedigree herds where a line-breeding system has been followed, and also less in the single purpose dairy breeds, than in those which claim dual-purpose qualities.

The experience of breeders, nevertheless, has made it clear that cows which are good dairy animals do not necessarily have the power of passing on their own good qualities, either to their female or male progeny. This leads to a most important conclusion—that the *ability of a cow to transmit* its productive qualities is *distinct from* the *possession of* these qualities. We may therefore add another to the list of dairy qualities already given—(f) ability to pass on productive capacity to the progeny. From the breeder's point of view, this is the most important of all qualities, and if, in addition to the possession, to a more or less marked degree, of those qualities previously mentioned, the animals possessing it can be identified, some real progress has been made towards "certainty" in breeding.

Breeding value shown by progeny records.

Up to the present the only method whereby the possession of such prepotency can be discovered is by a study of the actual records of the *progeny*. With dairy stock, this requires a much longer time than with beef stock. It is possible in two breeding years to ascertain with a considerable degree of certainty the quality of the progeny of a beef cow, and still more so of a beef bull. With dairy stock, however, until external appearances can be more accurately interpreted, three or four breeding years must pass before the milk records of the progeny show the actual powers of transmission possessed by their parents. In the case of cows this delay is not serious, but with bulls it means that, as a rule, the sire is slaughtered some time before his real powers as a getter of dairy stock can be known.

In herds of pedigree stock, bulls are frequently retained until well on in years, but in the past in this country it has not been the practice to determine the breeding value of such bulls by a study of the records of the progeny. It is quite probable that some such bulls have been retained because of their dam's or their own show-yard record, or for other reasons which have no appreciable bearing on the transmission of dairy qualities.

There is some indication that this new point of view in the judging of dairy bulls is gaining ground, particularly among Friesian breeders, but it is so important that it deserves widespread publicity. This should lead to a fuller realization of the very true saying among farmers, that "the bull is half the herd."

For the purpose of obtaining a progeny record of a bull, it is necessary to have the milk records of the dams as well as those of the daughters, and the breeding value of the bull can be judged by the difference between the average record of the former and of the latter. To illustrate this important point, the progeny records of two bulls used in the herd at the University College Farm are shown below :—

Progeny Records of Bull "A."

	Dams	Daughters
Number of animals	8	8
Number of lactation periods	20	20
Average yield per lactation period	8,518 lb.	8,479 lb.
Loss per lactation period		39 lb.
Average lactation period	46·4 wks.	44·3 wks.
Average dry period	10·0 wks.	11·3 wks.
Average period between calvings	56·4 wks.	55·6 wks.
Gain between calvings	..	0·8 wks.

Note I. The dams were a selected group of cows purchased from different places, and they show a remarkably high average yield.

Note II. The 20 lactation periods of the daughters comprise more first and second periods than the 20 of the dams and a larger proportion of these periods commenced during the summer months, thus handicapping the daughters. When these two conditions are taken into account, it can confidently be said that the daughters were superior to the dams, showing that bull "A" possessed exceptional breeding value for milk production

Progeny Records of Bull "C."

	Dams	Daughters
Number of animals	9	12
Number of lactation periods	20	25
Average yield per lactation period	8,001 lb.	6,468 lb.
Loss per lactation period	..	1,533 lb.
Average lactation period	43·3 wks.	38·3 wks.
Average dry period	10·1 wks.	13·6 wks.
Average period between calvings	53·4 wks.	54·9 wks.
Gain between calvings	..	1·5 wks.

Note I. The dams include cows purchased for their apparent milking qualities, and several of the daughters of bull "A." The average yield is notably good.

Note II. The 25 lactation periods of the daughters include 5 more first and second periods than the 20 of the dams, and to a certain extent this handicaps the daughters. The season of calving gave no advantage to either group. The yields show that bull "C" lacked the breeding value for milk production of bull "A," but was nevertheless a useful dairy bull.

The above results show that bull "A" was capable of siring female progeny which gave an average milk yield of 8,479 lb. in an average lactation period of 44·3 weeks, and which were at least equal to their dams in productive powers. The heifers and cows got by bull "C" averaged 6,468 lb. in 38·3 weeks, and failed to equal the record of *their* dams by 1,533 lb. These figures show conclusively that "A" was much the better bull for breeding purposes ; he was, in fact, a bull worthy of a place in the best pedigree Dairy Shorthorn herd in the country. Unfortunately, following the usual custom, he was sold for slaughter before any of his progeny came into milk.

Progeny tests of bulls.

It is obvious that information from progeny records cannot be obtained in a short time, and that the extended use of bulls which have proved their value, involves a change in practice in regard to the age to which bulls are kept. Under ordinary conditions, bulls are used for two to three years, and fattened for slaughter when three to four years old. So long as this practice is continued, the use of tested sires is impossible. With the larger breeds of dairy cattle, a bull will be four to four and half years old before the oldest of his heifers calve down, and about five years old before they

complete a lactation period. It may be possible to form a reliable opinion as to the lack of dairy qualities of these heifers by their poor udder development before, and low milk yield just after calving, but, if the heifers promise well, it is not possible to distinguish between the good and the very good until well on in the lactation period. The progeny test, therefore, can only give information in terms of milk yield for bulls of five years and over, and to be of maximum value the bulls must be healthy and active for some time thereafter.

In herds of pedigree stock, it is not uncommon to find bulls kept for as many years as they retain their usefulness, but the dairy farmer with non-pedigree cows sees many difficulties in keeping a bull until he is five years old. If the farmer is to avoid in-breeding, a second bull must be bought to serve the progeny of the first one, and few herds are large enough to warrant the keeping of two bulls, while old bulls occasionally develop bad tempers and become dangerous to handle, but this difficulty may largely be overcome by more careful housing, handling and regular exercise. Further, the possibility that, should the progeny test show the bull to be very deficient in power to transmit dairy qualities, the cost of two additional years' keep will be incurred without any return, makes farmers less willing to undertake the trial.

The most economical solution of this difficulty appears to lie in the co-operation of two or more neighbouring farmers. Two promising bulls might be purchased for two herds, on the understanding that during the first three years they should so used approximately equally in both herds, and if one bull were found to be of great dairy prepotency, he would be kept as long as possible for mating with mature and unrelated cows. Under these conditions, however, judicious in-breeding most probably would give very satisfactory results. Such a scheme could be worked equally well with three participants. The same system could be followed without the risk of differences of opinion where one owner maintains a large herd or has cows at two or more homesteads. Young bulls would be required from time to time for mating with heifers, as is the custom at present.

The co-operative societies of small holders organized under the Ministry of Agriculture's Live Stock Improvement Scheme could adopt the tested sire system. Bulls could be transferred from one society to another, and the societies would have the advice and assistance of the Live Stock Officer at all stages. The period necessary for a progeny test could also probably be shortened by good management and feeding of the young stock, and by mating at an earlier age than usual.

Owners of pedigree herds who have confidence in the bulls they offer for sale, might also come to some agreement with purchasers as to the retention of a bull for the necessary time, since, when a specially good bull is found, the family from which he is bred immediately increases in value.

Progeny tests of cows.

Tests of the power of transmission of dairy qualities in cows are not, of course, of the same importance as in the case of bulls. A cow will, on the average, have but five or six calves in a breeding herd, and as only half of these may be heifers, individual cows with the maximum power of transmission can, through their female progeny, make only a small contribution to the improvement of the herd. The basis of selection of cows for breeding must, nevertheless, be facts—not opinions—hence the need for a great development of milk recording to supply information on the degree to which dairy qualities are possessed by cows in the herd. The need for constitution must also be kept in mind; and, lastly, "foundation" cows should exemplify to a marked degree the type and characteristics of the breed.

Registers of heavy-milking cows and of dairy bulls.

Reference may also be made to the formation of registers of heavy-milking cows in relation to the breeding of dairy bulls. Registers of cows complying with certain conditions as to minimum yield, and other particulars, are now compiled by the Ministry of Agriculture, the Dairy Shorthorn Association, and at least one Breed Society, and one of the advantages claimed for such registers

is that they afford a basis for a register of bulls out of cows with authenticated yields. The emphasis already laid on the distinction between possession of dairy qualities and *power of transmission*, and on progeny tests, indicates another basis which might be adopted for entry into a register of bulls.

A register of bulls which have a minimum number of female progeny *qualifying for entry* into the registry of heavy-milking cows, will be a more valuable guide to breeders than a list of bulls out of registered cows. The entry of a bull into such a register would add greatly to its own value and to the value of its family, and the information would be an invaluable complement to pedigrees and of great assistance in selecting animals for any particular application of the line-breeding system.

SUMMARY.

From the individual breeder's point of view, success in breeding for milk production is most likely to be attained by working steadily towards an attainable ideal embodying type, constitution, breeding powers and dairy qualities; by the selection of cows conforming as closely as possible to this ideal; by the study of pedigree and milk records; and by the use of bulls, good animals in themselves, and possessing some considerable degree of concentration of the blood of a family of cows (*i.e.*, line-bred) showing the desired type and characteristics, and the required degree of dairy qualities. If an aged bull of the desired breeding and the sire of progeny of known merit can be obtained, a definite advance should be assured.

From the breed point of view, success lies in the direction of the identification and increase of families and animals possessing breed characteristics, dairy qualities, and the power of transmitting them to the utmost possible extent; the adoption of a uniform method of stating milk yields; the certification of milk yields and percentage of fat by an external authority; the development of registers for heavy-milking cows, with classes for different ages from the age of first calving to maturity and the formation of registers of bulls with a minimum number of daughters entered in the heifer and cow registers.

From the national point of view, breeding for milk production would be assisted by the inauguration of a scheme for the collection of data on the possession and inheritance of dairy qualities and for the study of this data at the Institute for Research in Animal Breeding.

INTENSIVE CULTIVATION DURING THE WAR.*

ALTHOUGH the work which intensive cultivators accomplished during the war is small in comparison with the great work performed by British agriculturists, yet nevertheless it is in itself by no means inconsiderable, and is, moreover, significant, and deserves a brief record. That work may have turned and probably did turn the scale between scarcity and sufficiency; for, as I am informed, a difference of 10 per cent. in food supplies is enough to convert plenty into dearth. Seen from this standpoint the war-work accomplished by the professional horticulturist—the nurseryman, the florist, the glass-house cultivator, the fruit-grower and market gardener—and by the professional and amateur gardener and allotment holder assumes a real importance, albeit that the sum total of the acres they cultivated is but a fraction of the land which agriculturists put under the plough.

As a set-off against the relative smallness of the acreage brought during the war under intensive cultivation for food purposes, it is to be remembered that the yields per acre obtained by intensive cultivators are remarkably high. For example, skilled onion-growers compute their average yield at something less than five tons to the acre. A chrysanthemum-grower who turned his resources from the production of those flowers to that of onions obtained, over an area of several acres, a yield of 17 tons per acre. The average yield of potatoes under farm conditions in England and Wales is a little over six tons to the acre, whereas the army gardeners in France produced, from Scotch seed of Arran Chief which was sent to them, crops of 14 tons to the acre. Needless to say, such a rate of yield as

* Extracted from the Presidential Address of Professor Frederick Keeble, C.B.E., Sc.D., F.R.S., to the Agricultural Section, British Association, Cardiff. Reprinted from *The Jour. of the Royal Society of Arts*, dated 8th Oct., 1920.

this is not remarkable when compared with that obtained by potato-growers in the Lothians or in Lincolnshire, but it is nevertheless noteworthy as an indication of what I think may be accepted as a fact, that the average yields from intensive cultivation are about double those achieved by extensive methods.

The reduction of the acreage under soft fruits, strawberries, raspberries, currants and gooseberries, which took place during the war gives measure of the sacrifices—partly voluntary, partly involuntary—made by fruit-growers to the cause of war-food production. The total area under soft fruits was 55,560 acres in 1913, by 1918 it had become 42,415, a decrease of 13,145 acres, or about 24 per cent. As would be expected, the reduction was greatest in the case of strawberries, the acreage of which fell from 21,692 in 1913 to 13,143 in 1918, a decrease of 8,549 acres, or about 40 per cent. It is unfortunate that bad causes often have best propagandas, for were the public made aware of such facts as these, they would realize that that the present high prices of soft fruits are of the nature of deferred premiums on war-risk insurances, with respect to which the public claims were paid in advance and in full.

I should add that the large reduction of the strawberry acreage is a measure no less of the shortsightedness of officials than of the public spirit of fruit-growers; for, in the earlier years of the war, many counties issued compulsory orders requiring the grubbing up and restriction of planting of fruit, and I well remember that one of my first tasks as Controller of Horticulture was to intervene with the object of convincing the enthusiasts of corn production that, in war, some peace-time luxuries become necessaries and that, to a sea-girt island beset by submarines, homegrown fruit most certainly falls into this category.

Those who were in positions of responsibility at that time will not readily forget the shifts to which they were put to secure and preserve supplies of any sorts of fruit which could be turned into jam—the collection of blackberries, the installation of pulping factories which Mr. Martin and I initiated, and the rushing of supplies of scarcely set jam to great towns, the populace of which, full of a steadfast fortitude in the face of military misfortune, was ominously

losing its sweetness of disposition owing to the absence of jam and the dubiousness of the supply and quality of margarine.

But though the public lost in one direction it gained in another, and the reduction of soft-fruit acreage meant reckoned in terms of potatoes—an augmentation of supplies to the extent of over 100,000 tons. Equally notable was the contribution to food production made by the florists and nurserymen in response to our appeals. An indication of their effort is supplied by figures which, as president of the British Florists' Federation, Mr. George Munro—whose invaluable work for food production deserves public recognition—caused to be collected. They relate to the amount of food production undertaken by 100 leading florists and nurserymen. These men put 1,075 acres, out of a total of 1,775 acres used previously for flower-growing, to the purpose of food production, and they put 142 acres of glass, out of a total of 218 acres, to like use. I compute that their contribution amounted to considerably more than 12,000 tons of potatoes and 5,000 tons of tomatoes.

The market growers of Evesham and other districts famous for intensive cultivation also did their share by substituting for luxury crops, such as celery, those of greater food value, and even responded to our appeals to increase the acreage under that most chancy of crops—the onion—by laying down an additional 4,000 acres and thereby doubling a crop which more than any others supplies accessory food substances to the generality of the people.

In this connection the yields of potatoes secured by Germany and this country during the war period are worthy of scrutiny.

The pre-war averages were: Germany, 42,450,000 tons; United Kingdom, 6,950,000 tons; and the figures for 1914 were: Germany, 41,850,000 tons, United Kingdom, 7,476,000 tons.

Germany's supreme effort was made in 1915 with a yield of 49,570,000 tons, or about 17 per cent. above average. In that year our improvement was only half as good as that of Germany: our crop of 7,540,000 tons bettering our average by only 8 per cent. In 1916, weather played havoc with the crops in both countries, but Germany suffered most. The yield fell to 20,550,000 tons, a decrease of more than 50 per cent., whilst our yield was down to

5,469,000 tons, a falling off of only 20 per cent. In the following year, Germany could produce no more than 39,500,000 tons, or a 90 per cent. crop, whereas the United Kingdom raised 8,604,000 tons, or about 24 per cent. better than the average. Finally, whereas with respect to the 1918 crop in Germany no figures are available, those for the United Kingdom indicate that the 1917 crop actually exceeded that of 1918.

There is much food for thought in these figures, but my immediate purpose in citing them is to claim that of the million and three-quarter tons increase in 1917 and 1918, a goodly proportion must be put to the credit of the intensive cultivator.

I regret that no statistics are available to illustrate the war-time food production by professional and amateur gardeners. That it was great, I know, but how great I am unable to say. This, however, I can state, that from the day before the outbreak of hostilities, when, with the late Secretary of the Royal Horticultural Society, I started the intensive food-production campaign by urging publicly the autumn sowing of vegetables—a practice both then and now insufficiently followed—the amateur and professional gardeners addressed themselves to the work of producing food with remarkable energy and success. No less remarkable and successful was the work of the old and new allotment holders, somuchso indeed that at the time of the Armistice there were nearly a million and a half allotment holders, cultivating upwards of 125,000 acres of land : an allotment for every five households in England and Wales. It is a pathetic commentary on the Peace that Vienna should find itself obliged to do now what was done here during the war, namely, convert its parks and open spaces into allotments in order to supplement a meagre food supply.

This brief review of war-time intensive cultivation would be incomplete, were it to contain no reference to intensive cultivation by the armies at home and abroad. From small beginnings, fostered by the distribution by the Royal Horticultural Society of supplies of vegetable seeds and plants to the troops in France, army cultivation assumed, under the direction of Lord Harcourt's Army Agricultural Committee, extraordinary large dimension : a bare summary

must suffice here, but a full account may be found in the report presented by the Committee to the Houses of Parliament and published as a Parliamentary Paper.

In 1918 the armies at home cultivated 5,869 acres of vegetables. In the summer of that year the camp and other gardens of our armies in France were producing 100 tons of vegetables a day. These gardens yielded, in 1918, 14,000 tons of vegetables, worth, according to my estimate, a quarter of a million pounds sterling, but worth infinitely more if measured in terms of benefit to the health of the troops.

As the result of General Maude's initiative, the forces in Mesopotamia became great gardeners, and in 1918 produced 800 tons of vegetables, apart altogether from the large cultivations carried out by His Majesty's Forces in that wonderfully fertile land. In the same year the forces in Salonika had about 7,000 acres under agricultural and horticultural crops, and raised produce which effected a saving of over 50,000 shipping tons.

THE DYNAMOMETER FOR THE LINCOLN TRIALS.*

THERE is a limit to the extent of the accuracy of the results obtainable from a tractor trial like that which is to take place at the end of September this year at Lincoln. The difficulty is that precisely similar conditions for a large number of competitors are unattainable, and even the smallest variation in a matter of this kind may produce effects quite out of proportion to the difference in the conditions. It is partly for this reason that I have always held that a purely competitive event is not only impracticable, but unfair to the competitors, as an element of chance is introduced which should not obtain when dogmatic statements as to the comparative merits of the machines tested are to be made.

Let us take, for example, the simple operation of ploughing. It is a straightforward operation, seemingly, and, quite rightly, is made the basis of any comparative tests of agricultural tractors. It might be thought that, provided that each tractor was set to pull the same type and make of plough, and if all were put in the same field, the results would be fairly comparable. If a perfectly flat field were to be selected, and if it were homogeneous throughout; if the tractors all ran at the same speed, and if all ploughed to the same width and depth, then the results would be comparable. But it will be observed that the comparison would only then be possible in respect of the fuel consumption, since the conditions have ensured that the acreage ploughed per unit of time will be the same for every tractor. Moreover, since all those machines will not be designed to travel economically at the one speed, little satisfaction will be afforded by the results which accrue from the test. As this is only one aspect of the matter, and as there are a great many such aspects, it is evident that the people who are responsible for the carrying out of a

* Reprinted from *Country Life*, dated August 14, 1920.

test on the lines of this year's trials have embarked on a work of considerable magnitude.

However, having decided irrevocably, as it seems, on a competitive test, the Royal Agricultural Society, who were responsible for that decision, and the Society of Motor Manufacturers and Traders, who have definitely made up their minds to collaborate with the senior body in this matter, undoubtedly took a step in the right direction when they decided to compel every competitor in any one class to operate the same type and make of plough. Considerable dissatisfaction, due in the main to misunderstanding, has arisen out of this decision, and I have been requested to elucidate one or two points concerning it.

The original decision to make that condition arose, as I have indicated, from a desire to arrange for equal conditions for all those machines, which were directly in competition with one another. The trial is essentially one of tractors only, and not of implements. Having decided to use, in each class, one make of plough only, the next point which arose was, "which plough shall we select?" It was felt to be desirable to avoid, so far as possible, the making of any invidious distinctions between the various types of implement on the market, and several plans for making the choice were discussed. It was even suggested, I understand, that a composite implement should be constructed from various parts, purchased from different makers, but this was regarded as going a bit too far. Eventually it was decided that, as a preliminary, foreign ploughs should be eliminated and only British ploughs used. The idea was not a very startling or original one, and although the elimination of the American plough naturally caused a little heart-burning among importers of those implements, it is obvious that the same grievance is anyhow to be meted out to all but a few—three, as it has turned out—of our British makers. I do not think the matter is one of great moment. It is certainly time that someone gave the British manufacturer a bit of a leg up. The R. A. S. of England at least is justified in making some such discrimination.

At any rate, by this simple process of elimination, the number of makes of implements from which the choice had to be made was

considerably and conveniently reduced, actually, as it proved, to six, who offered to put their implements at the disposal of the society for the trial. This offer was by no means one to be considered lightly, as it involves in one case the provision of no fewer than twenty-eight self-lift three-furrow ploughs, with an adequate supply of spare parts and the attendance of the necessary experts to ensure that they are set properly for the work.

The final selection was made on a basis of pure chance, the six names being thrown into a hat and those which were drawn out first being selected for the honour—and responsibility—of providing the implements. As is now pretty widely known, the selected ploughs are the Hornsby two-furrow, the Ransome three-furrow and the Martin four-furrow. It is important to note that the choice of these implements rested on chance only so that while there is no actual merit attaching to the selection, it is equally true that the mere fact of a maker's plough not having been chosen, does not in any way reflect on the capacity either of the plough or its maker.

In the endeavour to ensure that all the tractors in any one class shall operate.

The Drawbar Dynamometer

under equal conditions, the provision of the same type of plough for each is a step in the right direction. It does not, however, go far enough. It is impracticable to arrange that each and everyone of them shall work in soil of precisely the same consistency, so that measures have to be taken to calibrate in some way or other the actual effort which each machine is exerting. The simplest way to do this is to ascertain the actual pull which is being exerted through the tractor drawbar. For this purpose what is termed a drawbar dynamometer is used, and in these important trials, to eliminate any possibility of error owing to differences in the actual reading of the instrument, it is arranged that the actual pull shall be recorded on a chart. Last year, as may be remembered, two of these dynamometers were used, one made by the National Physical Laboratory, the other being of American manufacture. The former was used for the measurement of the drawbar pull of the tractor, when it was

exerting its maximum, and for the purpose of arranging the pull, a loaded trailer waggon was used with the dynamometer mounted on the front. When measuring the drawbar pull exerted while ploughing, the American dynamometer was used, as being better adapted for the purpose.

The machine which will be used this year is a much better instrument than either of those used last year. It has been designed at the N.P.L., principally, I believe, by Mr. J. T. Hyde, under the supervision of Dr. Stanton of the Engineering Department of the Laboratory. It can be used for measuring the drawbar effort in practically any circumstances which are likely to arise. The dynamometer itself consists simply of a barrel and plunger, which is inserted between the tractor and the implement or trailer which it is hauling. The barrel is full of oil, and as the tractor commences to move the pull which it exerts is transmitted to the oil as pressure. Communication is effected by means of a flexible pipe between the oil in the barrel and the recording apparatus, which is in principle simply a needle and pencil, the latter in contact with a sheet of paper wound on a drum. As the pressure waxes and wanes, the pencil rises and falls and thus records the pull of the tractor. [Cultor.]

DOMESTIC FRUIT BOTTLING WITH OR WITHOUT SUGAR.*

FRUIT which is left exposed to the air will go bad. It may be preserved almost indefinitely if it is properly bottled. The reason why perishable fruits go bad so quickly is that under ordinary conditions the germs of decay present on their surfaces begin to grow, increase in numbers, and set up decomposition in the fruit. These germs may be already present on the fruit when it is put into the bottle, or, unless the bottle containing the preserved fruit is made air-tight, small quantities of air passing into the bottle may carry them in with it. In order to preserve fruit it is necessary (1) to destroy or stop the growth of any germs already on the fruit, and (2) to seal the jar containing the fruit so that further organisms in the air are prevented from reaching it.

These objects are carried out by placing the fruit to be preserved in a suitable jar and then raising the temperature sufficiently to destroy or render inactive any germs present on the fruit. This having been done, the jar is sealed so as to prevent germs from entering from the outside. The method of destroying the organisms or rendering them inactive is termed pasteurization, and usually consists in heating the fruit in water or in syrup, though the fruit may also be heated whilst in a dry state, boiling water or syrup being poured over it afterwards to prevent it from drying during storage.

Bottling is the most economical method of fruit preservation at the present time when sugar is dear, because —

(*a*) The use of sugar is not essential.

(*b*) The process is simple and inexpensive.

(*c*) Fruit can be preserved whole for tarts or stewing or in pulp for jam-making at a later period.

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* Reprinted from *The Jour. of the Min. of Agri.*, Vol. XXVII, No. 6.

In view of the world shortage of sugar, the bottling of whole fruit cannot be too strongly recommended, because of all methods of preservation, this requires the least amount of sweetening to render the fruit sufficiently palatable for table use.

METHOD WITH SPECIAL BOTTLES OR JARS : APPARATUS REQUIRED.

(*a*) *Bottles.* Screw top or clip top glass jars are usually obtainable from any ironmonger. The cheapest type of jar has a tin lid, but this is not so good as the others mentioned. Screw top jars are the best, though those supplied with a metal spring are quite satisfactory. Before use, the bottles—particularly new ones—should always be tested for flaws, as the seating for the rubber bands is apt to be imperfect; sometimes a small ridge is left at this point in the making, and must be removed with a file in order that the cap will fit quite evenly with no sign of rocking.

(*b*) *Sterilizer.* When small quantities of fruit are to be bottled, a large saucepan, boiling pan, fish kettle, or similar vessel for heating water will suffice, provided it is deep enough. For fairly large quantities, a pan holding one or two dozen bottles is necessary. A sterilizing outfit (several makes of which are on the market) may be usefully employed.

In using any ordinary pan as a sterilizer it is essential that a false bottom be fitted, as the bottles must not touch the bottom of the sterilizer or boiling pan. A wire frame or strips of wood nailed together trellis fashion will answer the purpose.

(*c*) *Thermometer.* For successful work a thermometer is necessary. One of a "floating dairy" type which registers not less than 212°F. is very convenient, or the rather heavier stem variety answers quite well. A rubber washer will hold it in position.

It is essential that great care be exercised in the choice and renewal of rubber rings, as faulty ones are often the cause of failure. When rings are kept from one year to another they are apt to "perish." Unperished rings, when stretched, will return to their original size, and when pinched, will not crease. It is cheaper to cast a doubtful ring than lose a jar of fruit.

SELECTING AND PREPARING THE FRUIT.

Slightly under-ripe fruit gives the best results in bottling. If all the fruit are not of this class, the ripe and unripe fruit should be separated and treated independently. Grade carefully so that each bottle contains even-sized specimens. Wash well in cold water, with the exception of fruit like raspberries and loganberries; these would lose flavour if so treated. Preparation before bottling varies somewhat according to the fruit, *e.g.*, gooseberries should be topped and tailed; currants lightly shredded from their stalks; rhubarb skinned and cut into pieces of a uniform size; cherries must be stalked, and, if possible, stoned; the hulls should be removed from raspberries; large juicy plums may be cut in half before being placed in the bottle; peaches and nectarines should be skinned, stoned and halved; apples and pears must be peeled and "quartered." A silver or plated knife only should be used for preparing fruit.

PASTEURIZING.

Pack as tightly as possible the bottles without bruising the fruit. Fill the bottles with cold water to overflowing. Place on the rubber ring, cap, and screw band or clip; screw up and then release slightly to allow air to escape during pasteurization. Clips or springs allow the air to escape automatically. Place the bottles in the pan in which they are to be pasteurized, the cold water in the pan being within an inch of the tops of the bottles. Different fruits require different treatments, but for most fruits the following method will be found satisfactory:—

(*a*) *With thermometer.* Bring to the required heat slowly at the rate of approximately 2°F. per minute. A temperature of 155° to 180° is necessary. (*See* time table given below.)

(*b*) *Without thermometer.* Bring the water very slowly to simmering, or until the hand cannot be held on the pan lid. When this point is reached, lift up a bottle for examination. If the fruit is still firm in the bottle put it back in the pan, but so soon as it begins

to move about when the bottle is twisted, it is ready to come out.

Should the water in the pan become too low through boiling, more should be added, but it must be of the same temperature as that in the pan.

When ready, the bottles should be removed, the covers at once securely fastened down, and the bottles allowed to cool slowly. Hot bottles must not be placed on anything cold, or they may crack. When quite cold, remove the screw or clip and test the seal by lifting the bottle by the cover. This test is possible if the bottle and fittings are perfect. If the lid lifts off the fitting is imperfect. Find the fault and remedy it, then re-pasteurize.

TIME TABLE.

Fruit	Method	Temperatures	Times
All soft and stone fruits	Starting with cold water inside and out	155°	1½ hours, rising to 140° in first hour, and to 155° for next half hour. Maintain at 155° for 10 to 15 minutes for stone fruits, and at 155° for 5 minutes only for soft fruits.
Apples and pears	As above	180°	1½ hours, rising to 150° in first hour, and to 180° in next half hour. Maintain at 180° for 10 to 15 minutes.
Syruped fruit	Cold syrup inside	10° higher than for each above.	1½ hours, as for each above.

"DRY" METHOD OF BOTTLING.

This method, which is more particularly suited for plums and gooseberries, is very simple and gives results somewhat superior as regards flavour to those obtained by the foregoing methods.

Pack the fruit tightly in the bottles and place in a slow oven until the fruit shrinks slightly ; it is then ready to come out. Have boiling water ready, remove one bottle, fill up with the boiling water, and fasten securely before taking another bottle from the oven. See that the lids and fittings are warm before being placed on the bottles. This method may be adopted with special bottles, or with ordinary bottles or jars sealed as described below.

Bottling in ordinary bottles and jars.

Glass jars with a special device for sealing are to be preferred, and their use is strongly recommended, but if they cannot be obtained, ordinary wide-necked bottles or jars may be used and sealed by one or other of the methods described below. The necks of the bottles should not be larger than is necessary for the insertion of the fruit, and should be so formed that air can be absolutely excluded by sealing. The chief difficulty in using ordinary bottles and jars is that of securing a sufficiently germ-proof seal. Several forms can be made to serve, if carefully applied, but it is advisable to examine the bottles in store from time to time in case fermentation or mould-growth occurs in any of them. If this happens, the contents should be consumed without delay, or the affected fruit should be treated again and resealed. Ordinary bottles or jars should not be packed so full of fruit as special bottles, on account of the sealing necessary to render them air-tight. Otherwise, pasteurization should follow the lines of bottling in special bottles.

Methods of sealing.

The old method of tying a piece of bladder over the mouth of the bottle is fairly satisfactory. Bullock bladders, obtainable from a butcher, should be washed and soaked in warm water to soften them before use. They should be tied on with string, having been cut previously into pieces of such size as will leave a fair-sized margin below the string after tying. Better results are obtained by purchasing parchment paper jam covers for pasting or gumming on, provided that the bottles are afterwards kept in a cool, dry place. Corks may be used instead of bladders, scalding them well first and then after insertion, sealing the tops with sealing or bottle-wax. Mutton fat is sometimes used. It is poured on the surface of the water in the bottle so as to form, when cool, a solid block of fat in the mouth of the bottle.

Other methods are :—

(*a*) Two layers of parchment paper, pasted or gummed separately, one over the other, placed over the bottle and tied with fine string.

(*b*) Three or four layers of writing or ordinary paper, pasted, gummed, or starched separately, one over the other, and then tied tightly with fine string.

(*c*) Three or four layers of tissue paper dipped in milk and placed separately over the mouth and tied tightly with fine string.

(*d*) Calico, linen or cloth, cut to size, with paper rounds to lie exactly on the top of the bottle. Melt together 1 lb. of resin, 2 oz. of bees-wax, and 2 oz. of tallow, and paint the cut pieces of material. This sets in a few minutes, and a large number may be made at one time. To use, place the piece of paper on the bottle, lay the prepared seal over it and tie round.

The use of syrup.

The use of syrup is not essential, pure water being equally suitable and rather more transparent. Moreover, a thin syrup affects the natural flavour of the fruit without making it sufficiently sweet to render further sweetening unnecessary. Should sugar be desired, a syrup may be made by adding $\frac{1}{2}$ lb. to $1\frac{1}{2}$ lb. of sugar to one quart of water, and boiling until the sugar is dissolved. If syrup is used for " dry " bottling, it may be added to the fruit when boiling in lieu of boiling water. If used for the other methods of bottling, it should be poured on the fruit before pasteurization, in place of water.

The use of saccharine.

The use of saccharine as a sweetening agent for bottled fruits is not recommended, but may be used preferably when such contents are opened for table use. It is of the utmost importance that the solution made by dissolving saccharine in water should not be brought into contact with metal. For this reason it should be dissolved in a glass or cup and a wooden spoon used for stirring. On no account should it be used when bottles or jars having metal screw top fittings are employed. Saccharine should be added under the same condition as sugar (syrup) when bottling. The density of the solution will depend upon individual taste.

CAUSES OF FAILURE.

1. Over-ripe fruit.
2. Imperfect sealing.
3. Water too hot causing mushy contents. The temperatures must be strictly observed.
4. Cooking too long. The times given must not be exceeded.

POINTS TO WATCH.

1. Bottles must be scrupulously clean.
2. Make sure that the false bottom is in the pan before putting in the bottles, otherwise they will crack. Do not allow the bottles to touch the sides or this also will crack them.
3. Bottles should be screwed down tightly one at a time as they are taken out of the pan. Hot bottles must never he handled with a cold or damp cloth as this will crack them.

Notes

PUSA WHEATS IN AUSTRALIA.

For some years past a number of trials of Pusa wheats has been carried out in Australia both by the Government and by farmers interested in the improvement of wheat. One result has been the appearance of some of the new varieties, notably Pusa 4, in the list of prize winners at the various agricultural shows in that country.. During the current year (1920), Pusa 4, grown by Mr. W. H. Scholz at Gilgandra, gained the first prize in the strong white class at the Royal Agricultural Show held last Easter at Sydney. In this competition, the wheats were milled and from the figures published in the *Agricultural Gazette of New South Wales* of September last (Vol. XXXI, p. 627) it appears that this variety stood first in the Show and was awarded 92·5 points out of a total of 100. The judges in their report stated " the sample of the Indian wheat, Pusa No. 4, exhibited by Mr. W. H. Scholz, of Gilgandra, is worthy of mention. It yielded a high percentage of excellent colour flour of 53 quarts to the sack strength which was the highest water absorption of all the flours tested in the competition." The results of the complete milling tests were as follows :—

	Appearance of grain	Weight per bushel	Ease of milling	Percentage of flour	Colour of flour	Percentage of dry gluten	Strength	TOTAL
Maximum marks	10	15	10	10	15	20	20	100
Catalogue No. 6595	10	14·5	8	10	15	17	18	92·5

The bushel weight was 67 lb., the percentage of flour extracted 73·7 and the percentage of dry gluten 12·9.

Besides coming out first in the milling tests, Pusa varieties took a number of other prizes at Sydney. Pusa 4 and Pusa 107 were included in the collection which took the first prize for the five best strong wheats. Pusa 4 was one of the types in the list which took the second prize in this class. The same wheat is again mentioned among the five varieties which took the first prize for the best collection of non-Farrer wheats. [ALBERT HOWARD.]

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AN UNEXPLOITED SUPPLY OF CATTLE FODDER.

THE following is a reprint of a Bulletin by Dr. A. E. Parr and Babu Bisheshwar Dayal, published by the U. P. Department of Agriculture:

Baisurai (*Pluchea lanceolata*) is a very troublesome weed in several parts of the United Provinces, being particularly well-known in the districts of Aligarh, Muttra, Etáh, Agra, Jaunpore and Benares. It has a very deep and spreading root system. Its seed is very light and is blown long distances by the wind. In this way the pest is spreading into districts which a few years ago were free from it. It does much damage in *rabi* crops, particularly in tracks where irrigation is not available.

On account of its deep root system it grows much more rapidly than the unirrigated crop, and inspite of many and expensive weedings a great reduction in crop outturn is the result. After the *rabi* crop is harvested *baisurai* grows with great vigour through the hot dry months until the rains break.

It is then so thick on the ground that it often has to be cut by hand and burnt before ploughing can begin. During the rains it grows less vigorously and does little further damage till after the *rabi* crops are sown.

The Agricultural Department recently started a farm at Bichpuri in the Agra District. This farm is right in the *baisurai* tract and a special study of the *baisurai* weed and methods of dealing with it was commenced early this year. These experiments are still in their infancy, but they have already yielded results of considerable practical importance.

Baisurai in its younger stages is a succulent plant, with a good deal of leaf, and on this account it was thought advisable to try if some use could not be made of it as cattle fodder. Cattle grazing in a field, in which *baisurai* is growing, carefully avoid it on account of its disagreeable taste, and cultivators are under the impression that it cannot be fed to cattle.

To get rid of the bitter taste and make it more palatable a large number of preparations were tried with more or less success. The preparation which gave the most palatable result was obtained in the following very simple way.

Baisurai was cut and dried in the sun until the leaves were quite dry and brittle. This was then chopped up, mixed with *bhusa* and fed to bullocks. Small quantities of *baisurai* were given at first. The amount was gradually increased and the *bhusa* diminished until after ten days $\frac{1}{3}$—$\frac{1}{2}$ of the total fodder was *baisurai.*

We have now been feeding bullocks for five months on this mixture of *baisurai* and *bhusa* and have, for the sake of comparison, had other bullocks fed on *bhusa* alone. The cattle fed on *baisurai* and *bhusa* have kept in as good condition as the others, and the *baisurai* has had no bad effects on them.

An ordinary bullock will eat roughly about 20 pounds of *bhusa* or *juar* (*Sorghum*) stalks daily. In *baisurai* tracts, bullocks can safely be fed 12 pounds *bhusa* and eight pounds *baisurai* prepared as described above.

In the four districts of Aligarh, Muttra, Agra and Etah, there is a continuous tract of land about one million acres in area, all more or less infested with *baisurai.* This tract is roughly a square with Khair (Aligarh), Gobardhan (Muttra), Achnera (Agra) and Jalesar (Etah) marking the corners.

In this area of one million acres, in years of normal rainfall, over thirty lakhs of maunds of *baisurai* could be cut. In years of deficient rainfall the quantity would be much greater. In this area there are about 150,000 working bullocks. These bullocks during the eight months, from November to June inclusive, are fed chiefly on dry *juar* stalks and *bhusa.* They would consume per head during this period of eight months about 45 maunds of dry fodder. Of this, 20

maunds could be replaced by an equivalent weight of *baisurai* so that the total consumption of *baisurai* by the working bullocks of this tract would be 30 lakhs of maunds. The 30 lakhs of maunds of *bhusa* and *juar* fodder, thus released each year, would be available for sale or for building up reserve supplies.

At present prices this quantity would be worth not less than 15 lakhs of rupees.

In the whole of the United Provinces, probably not less than fifty lakhs of maunds of *baisurai* could be fed each year.

The famine of 1913-14 was the severest fodder-famine experienced in the United Provinces since 1878-79. Great efforts were made by Government and private agency to supply fodder from outside sources to keep the cattle alive. The total amount of fodder imported into the famine districts was slightly under forty lakhs of maunds, that is, considerably less than the total amount we estimate could be released each year by feeding available supplies of *baisurai* in these provinces.

An analysis supplied by the Officiating Agricultural Chemist to the United Provinces Government indicates that *baisurai* has a much greater feeding value than *bhusa* or *juar* stalks. Its value, as indicated by this analysis, may be expressed by saying that 20 pounds of *baisurai* is equal to 20 pounds of wheat *bhusa* plus three pounds of gram.

Feeding experiments are being carried on to see how this works out in practice.

In this note all we wish to bring out is that, within the limits laid down, dried *baisurai* can replace *bhusa* weight for weight in the fodder ration. At present we recommend that it should be fed to working bullocks only.

Its effect on young stock and milch cattle is being studied.

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ONE-WAY MOTOR-PLOUGHS.

A CORRESPONDENT writes in "The Times Trade Supplment," dated 28th August, 1920:—

Undoubtedly the most interesting of recent developments in British agricultural engineering is the one-way motor-plough,

which has appeared upon the British market in the form—judging from field experiments—of a successful model. Upon a commercial basis, this and other one-way ploughs will soon make their appearance, and so provide a triumph for British makers, which others have long striven to achieve, but without success.

The one-way motor-plough has features which recommend it to all farmers, whose arable land is divided into comparatively small areas, as in this country, and also to those agriculturists abroad who require to economize the space left at the headlands. One-way ploughing, moreover, is a simple procedure which native labour can follow with little preliminary guidance, for there is no demand upon the operator to exhibit skill in turning in a circumscribed area at the end of the furrow, and simultaneously to lift the plough out of work.

The reasons for the popularity of the one-way system, therefore, are obvious, and it is not surprising to learn that home and overseas inquiries for such an outfit are very numerous. Many large estate owners and farmers have made special but vain journeys to England hitherto to try to secure one-way motor-ploughs, and have had to return with what is really the second best for their needs, the self-contained motor-plough or cultivator.

The one-way motor-plough in the present case consists of six plough breasts, three being suspended from each end of the main carriage, which is modelled on the lines of a tractor body and is driven by an engine sufficiently powerful to haul three furrows in the heaviest clay land. The forward shares are held out of work as the motor-plough proceeds across the field, and automatically drop into work when the machine begins the return journey. Ploughing, therefore, becomes one succession of forward and return movements, and as headlands are not required for turning alone the compression of the land is declared to be very slight indeed.

This one-way motor-plough, and another of similar design, will compete at the Lincoln trials of the Royal Agricultural Society on September 28 and following days. As the two have never before been in competition in public, or had their work compared with tractors, much interest will be shown in the meeting. The first-

mentioned machine has the advantage that it can be used as a tractor to haul another implement or a laden wagon, for the ploughs can be removed.

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THE LINCOLN TRACTOR TRIALS : THE PRIZE WINNERS.

BEFORE giving the names of the winners in the various classes for tractors and ploughing engines at Lincoln, it may be as well to direct attention to the following list of the principal points to which the attention of the judges was directed :—(*a*) Weight of machine, (*b*) weight per inch, width of wheel and diameter of wheel, (*c*) mechanical design and construction, (*d*) adaptability to various kinds of work, such as harvesting and the like, (*e*) time taken to prepare for work, (*f*) ease and safety of handling, (*g*) ease of turning and space required for same, (*h*) efficiency of winding gear, (*i*) facility of attachment, (*j*) wheel devices, (*k*) attendance necessary, (*l*) consumption of fuel, water and other supplies per unit of work done, and (*m*) price.

There were seven classes in all, and in each the prizes offered were two in number, the first being a gold medal and £20, and the second a bronze medal and £10.

Class 1 was for internal combustion direct traction engine not exceeding 24 h.p. suitable for ploughing two furrows, 10 in. wide by 6 in. deep. Ten machines were entered in this class, out of which eight turned up and took part in the trials. The first prize went to the Case, entered by the J. I. Case Threshing Machine Company. The second prize went to the Cletrac, another American machine, marketed by H. G. Burford and Company, Limited, of 16, Regent Street, S.W.

Class 2 was for internal combustion direct traction engine not exceeding 30 h.p., suitable for ploughing three furrows. The first prize went to the British machine, the Peterbro'. This is a general purpose machine.

Class 3 was for internal combustion direct traction engine over 30 h.p., suitable for ploughing four furrows, 10 in. wide by 8 in.

deep. The first prize went to the Lauson, an American machine. There was no second prize awarded.

Class 4 was for direct traction steam engine plant, suitable for ploughing four furrows, 10 in. wide by 8 in. deep. There was only one entry in this class, the Mann steamer, but it certainly put up a remarkably good performance in every section of the trial. In the heavy land, for example, it was in what might almost be described as a field of lead, which it steadily ploughed without a stop throughout the whole of a day. It was also the only machine, among the heavy class, satisfactorily to perform on the hill climb (road haulage).

Class 5 was for double engine sets, with internal combustion power unit. There were only two entries, by John Fowler and Company (Leeds), Limited, and J. and H. McLaren, Limited. They both did well and were awarded the first and second prizes respectively.

Class 6 was also for double engine sets, this time driven by steam. There was only one entrant, John Fowler and Company (Leeds), Limited.

Class 7 was for self-propelled plough for ploughing not more than four furrows of not more than 10 in. wide by not more than 8 in. deep. The first prize went to the Crawley Agrimotor Company, Limited, for the well-known British machine of the same name. The Moline, an American, won the second prize. [*Country Life*, dated 16th October, 1920.]

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EXEMPTION OF AGRICULTURAL IMPLEMENTS WORKED BY POWER FROM CUSTOMS DUTIES.

THE following notification issued by the Government of India in the Department of Commerce is republished for information :—

In exercise of the power conferred by Section 23 of the Sea Customs Act, 1878 (VIII of 1878), the Governor-General in Council is pleased to exempt from the payment of import duty leviable under Parts III and IV of Schedule II to the Indian Tariff Act, 1894 (VIII of 1894), the following agricultural implements, when so

constructed as to be worked by power, other than manual or animal, namely :—

Winnowers, threshers, mowing and reaping machines, elevators, seed-crushers, chaff-cutters, root-cutters, ploughs, cultivators, scarifiers, harrows, clod-crushers, seed-drills, hay-tedders and rakes.

PERSONAL NOTES, APPOINTMENTS AND TRANSFERS, MEETINGS AND CONFERENCES, ETC.

MR. J. W. HEARN, I.C.S. (Punjab), is appointed as Under-Secretary to the Government of India, Department of Revenue and Agriculture, with effect from the 18th October, 1920, *vice* Mr. J. C. B. Drake, I.C.S., appointed Secretary, Board of Industries and Munitions.

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MR. ALBERT HOWARD, C.I.E., Imperial Economic Botanist, has been awarded the medal of the Royal Society of Arts for his paper on "The improvement of crop production in India" read in the Indian Section on May 31st, 1920. The Chairman of the meeting was Sir Robert W. Carlyle, K.C.S.I., C.I.E. The paper was published in the "Journal of the Royal Society of Arts" of July 16 and 23 last (Vol. LXVIII, Nos. 3530 and 3531, pp. 555–577).

***

MR. T. M. DOYLE, M.R.C.V.S., at present attached to the Government Cattle Farm, Hissar, is appointed temporarily to fill the post of Veterinary Officer at the Imperial Bacteriological Laboratory at Muktesar.

***

MR. H. C. SAMPSON, B.Sc., Deputy Director of Agriculture, Coimbatore, has been allowed combined leave for ten months.

***

MR. J. CHELVARANGA RAJU, Deputy Director of Agriculture Madras, is granted privilege leave for two months and 24 days.

HIS MAJESTY'S SECRETARY OF STATE FOR INDIA has been pleased to appoint Mr. A. C. Edmonds and D. G. Munro as Deputy Directors of Agriculture, Madras.

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MR. P. J. KERR, M.R.C.V.S., Superintendent, Civil Veterinary Department, Bengal, was on combined leave for 27 days from 27th November, 1920. Colonel A. Smith, F.R.C.V.S., Principal, Bengal Veterinary College, officiated as Superintendent in addition to his own duties.

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RAI RAJESWAR DAS GUPTA BAHADUR, Deputy Director of Agriculture, Northern Circle, Bengal, has been allowed leave for six months from the 15th November, 1920, Mr. Jadu Nath Sarkar, Superintendent of Agriculture, Burdwan Division, officiating.

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MR. DWIJADAS DATTA, B.Sc., M.S.A., Superintendent of Agriculture, is appointed to act as Second Economic Botanist, Bengal, with effect from the 3rd November, 1920, until further orders.

***

MR. D. QUINLAN, M.R.C.V.S., Superintendent, Civil Veterinary Department, Bihar and Orissa, is appointed to be Veterinary Adviser to the Local Government with effect from the 5th October, 1920.

***

MR. J. ROBINSON, N.D.D., Offg. Deputy Director of Agriculture, Patna Circle, Bihar and Orissa, was on privilege leave for 22 days with effect from the 6th November, 1920.

***

THAKUR MAHADEO SINGH, who has been appointed to the Indian Agricultural Service, has been posted as Assistant Agricultural Chemist, United Provinces.

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MR. W. TAYLOR, D.V.H., M.R.C.V.S., Professor of Pathology and Parasitology, Punjab Veterinary College, is appointed

Post-Graduate Professor, in addition to his own duties, with effect from the 16th October, 1920, relieving Captain E. Sewell, M.R.C.V.S., posted under the Superintendent, Government Cattle Farm, Hissar, for training.

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CAPTAIN U. W. F. WALKER, Officer under training in the office of the Chief Superintendent, Civil Veterinary Department, Punjab, is appointed Professor of Surgery in the Punjab Veterinary College, with effect from the 15th October, 1920.

***

MAJOR (TEMPORARY) F. G. SIKES, R.A.V.C., has been appointed temporarily to the Civil Veterinary Department in the Punjab, with effect from the 1st October, 1920, and is posted as Superintendent, Civil Veterinary Department, South Punjab.

***

MR. J. CLAGUE, I.C.S., is posted as Director of Agriculture, Burma, in place of Mr. J. St. C. Saunders, I.C.S.

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MR. A. MCKERRAL, M.A., B.SC., Deputy Director of Agriculture, Burma, has been granted an extension of leave for three months.

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COLONEL G. H. EVANS, C.I.E., C.B.E., Superintendent, Civil Veterinary Department, Burma, has been granted combined leave for nine months, with effect from the 28th November, 1920.

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ON return from combined leave, Mr. D. Clouston, C.I.E., M.A., B.Sc., has been reposted as Director of Agriculture, Central Provinces.

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ON relief by Mr. Clouston, Mr. F. J. Plymen, A.C.G.I., has been appointed Principal, Agricultural College, Nagpur.

ON relief by Mr. Plymen, Mr. S. T. D. Wallace, B.Sc., reverts as Assistant Director of Agriculture, Southern Circle, Central Provinces.

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ON return from leave, Mr. C. P. Mayadas, M.A., B.Sc., Assistant Director of Agriculture, has been appointed to officiate as Deputy Director of Agriculture, Western Circle, Central Provinces.

***

MR. H. COPLEY, who has been appointed by His Majesty's Secretary of State for India as Agricultural Engineer, Central Provinces, assumed charge of his duties at Nagpur on the 3rd December, 1920.

***

MR. A. G. BIRT, B.Sc., Deputy Director of Agriculture, Assam, has been granted an extension of leave on medical certificate for three months from the 23rd October, 1920.

Review

Plant Production and Fruit Culture in the Tropics.—By P. J. WESTER, Agricultural Adviser, Manila, 1920. 134 pages and 23 plates. (Manila : Bureau of Printing.)

THIS is a useful bulletin, giving a full account of up-to-date methods of plant propagation, particularly with reference to the Philippine Islands. As the author rightly remarks, the improvement of tropical fruits has not made much progress, and fruit culture in the Tropics is largely an unexplored field. Moreover, improvement in the case of fruit can be brought about only by means of vegetative propagation, which he describes "as the corner stone upon which rests modern fruit culture."

Hence the bulletin is devoted largely to describing methods of vegetative propagation. Propagation by cuttings, layering, grafting, inarching and budding is fully described and well illustrated, and a list of tropical fruit plants is given, showing in each case the best methods of propagating them.

The bulletin ends with brief directions for tree-planting and orchard management in general, and gives instructions regarding the chief insect and fungus pests of the Philippines, and the best methods of combating them. Altogether the bulletin is a useful publication and should be of value to those engaged in fruit culture and plant propagation in general in the Eastern Tropics. [G. P. H.]

NEW BOOKS

ON AGRICULTURE AND ALLIED SUBJECTS

1. The Chemistry of Crop Production, by T. B. Wood, C.B.E., M.A., F.I.C., F.R.S. (London: University Tutorial Press.) Price, 5*s*. 6*d*. net.
2. Plant Indicators: The Relation of Plant Communities to Process and Practice, by Frederic E. Clements. Pp. xvi+388+xcii plates. (Washington: The Carnegie Institution.) Price, 7 dollars.
3. A Text-book of Organic Chemistry, by E. de Barry Barnett. Pp. xii+380. (London: J. & A. Churchill.) Price, 15*s*. net.
4. Imperial Institute: Indian Trade Inquiry: Reports on Rice. Pp. ix+64. (London: J. Murray.) Price, 6*s*. net.
5. Keys to the Orders of Insects, by Frank Balfour-Browne. Pp. vii+58. (Cambridge: At the University Press.) Price, 7*s*. 6*d*. net.
6. Catalogue of the Lepidoptera (Phalænæ) in the British Museum Supplement. Vol. II: Catalogue of the Lithosiadæ (Arctianæ and Phalænoididæ) in the Collection of the British Museum, by Sir George F. Hampson. Plates xlii—lxxi. [London: British Museum (Natural History).] Price, 32*s*. 6*d*.
7. The Physical Basis of Heredity, by Prof. T. H. Morgan. (Monographs on Experimental Biology.) Pp. 305.

(Philadelphia and London: J. B. Lippincott & Co.) Price, 10*s*. 6*d*. net.

8. The Manufacture of Sugar from the Cane and Beet, by T. H. P. Heriot. (Monographs on Industrial Chemistry.) Pp. x+426. (London: Longmans Green & Co.) Price, 24*s*. net.
9. A Foundation Course in Chemistry: For Students of Agriculture and Technology, by J. W. Dodgson and J. Alan Murray. Second Edition, thoroughly Revised. Pp. xii+241. (London: Hodder and Stoughton, Ltd.) Price, 6*s*. 6*d*. net.
10. Elementary Agricultural Chemistry: A Handbook for Junior Agricultural Students and Farmers, by Herbert Ingle. Third Edition, Revised. Pp. ix+250. (London: Charles Griffin & Co., Ltd.) Price, 5*s*.
11. A Handbook of British Mosquitoes, by Dr. William Dickson Lang. Pp. vii+125+v plates. [London: British Museum (Natural History).] Price, 20*s*.
12. Recent Advances in Physical and Inorganic Chemistry, by Prof. A. W. Stewart. Fourth Edition. Pp. xvi+286+v plates. (London: Longmans Green & Co.) Price, 18*s*. net.

The following publications have been issued by the Imperial Department of Agriculture since our last issue:—

Memoirs.

1. "Kumpta" Cotton and its Improvement, by G. L. Kottur, B. Ag. (Botanical Series, Vol. X, No. 6.) Price, R. 1-12 or 3*s*.
2. Pebrine in India, by C. M. Hutchinson, B.A. (Bacteriological Series, Vol. I, No. 8.) Price, Rs. 3-8 or 5*s*. 6*d*.
3. The Gases of Swamp Rice Soils. V.—A Methane-oxidizing Bacterium from Rice Soils, by P. A. Subrahmanya Ayyar, B.A. VI.—Carbon Dioxide and Hydrogen in relation to Rice Soils, by W. H. Harrison, D.Sc. (Chemical Series, Vol. V, Nos. 7 and 8.) Price, As. 12 or 1*s*. 3*d*.

Reports.

4. Report of the Proceedings of the Third Entomological Meeting, held at Pusa in February 1919. Price, Rs. 17-8 for a set of three volumes.
5. Scientific Reports of the Agricultural Research Institute, Pusa (including the Report of the Secretary, Sugar Bureau), for the year 1919-20. Price, R. 1.

THE PURPLE HONEY-SUCKER (*ARACHNECHTHRA ASIATICA*)

Original Articles

SOME COMMON INDIAN BIRDS.

No. 8. THE PURPLE SUN-BIRD OR HONEY-SUCKER (*ARACHNECHTHRA ASIATICA*).

BY

T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S.,
Imperial Entomologist;

AND

C. M. INGLIS, M.B.O.U., F.E.S., F.Z.S.

THE Magpie Robin described in our last article is by no means the only bird whose cheery notes enliven our compounds. Conspicuous amongst the smaller feathered songsters and appealing both to eye and ear are the exquisite little Sun-birds or Honey-suckers, of which the males, clothed in metallic colours, are amongst the most beautiful of the birds which occur in India. We have none of those lovely little gems, the Humming-birds, which flash splendidly from flower to flower in South America, but we may almost imagine that we have when we see a tiny bird, clad in the most brilliant purple plumage, hovering over a flower with rapidly vibrant wings and extracting nectar with its long tongue, quite in the manner of a Humming-bird or Hawk-moth. Such a bird is almost sure to be the male of one of our species of Sun-birds belonging to the genus *Arachnechthra*, of which about eight species occur within Indian limits, but of these only three are commonly distributed in the Plains: Loten's Sun-bird (*Arachnechthra lotenia*), which occurs in Ceylon and Southern India, being wholly dark metallic purple

above, with a snuff-brown abdomen and a long curved beak; the Purple Sun-bird (*A. asiatica*), which is found throughout the Plains of India and in Ceylon, but is only a summer visitor to the Punjab, being very similar to the preceding, but with a violet black abdomen and a shorter curved beak; and the Purple-rumped Sun-bird (*A. zeylonica*), which occurs in Ceylon, Southern and Central India, but not in Northern India or Burma, and is distinguished from the other two by its bright yellow lower plumage and crimson back. The females of these three species do not possess the brilliant metallic coloration of their mates and have to be content with a dress which is earthy-brown or greenish-brown above and yellow beneath.

The above-mentioned birds belong, as already stated, to the genus *Arachnechthra*, but we have altogether some twenty-five species of Sun-birds within Indian limits and these are divided into four genera, the largest genus in point of numbers being *Æthopyga*, containing those birds in which the males have lengthened middle tail-feathers and yellow rumps. In this genus the commonest Plains species is the Himalayan Yellow-backed Sun-bird (*Æthopyga seheriæ*), a bird with most of the upper plumage crimson, as is likewise the lower plumage as far as the breast; it also has a purple moustache-like streak and the lengthened tail-feathers are metallic green. This Sun-bird is common in the Plains of North-Eastern Bengal, Assam and Cachar, and is also found along the foot of the Himalayas, which it ascends to a considerable height. It is parasitized in Assam by the Emerald Cuckoo (*Chrysococcyx maculatus*), and we have taken several of this Cuckoo's eggs from the nest of this Sun-bird.

In their habits all the species are very similar, frequenting flowering trees and shrubs, extracting the nectar from the flowers with their long tubular tongues, either occasionally hovering on the wing or more frequently clinging to slender twigs. But, besides carrying out the poet's dictum,

"For he on honey-dew hath fed,"

these little birds variegate their diet with small insects, for catching which their long bills are admirably adapted, both mandibles being

serrated along the terminal third of their length. Small spiders, caterpillars, beetles, bugs and flies, probably in most cases themselves visitors to flowers, fall a prey to these birds. We have also seen the Purple Sun-bird picking insects from off the ground and also flying up and catching them on the wing.

Besides being useful in helping to reduce the numerous insects which haunt our gardens, Sun-birds are also directly beneficial by helping to pollinate many flowers. Writing of *A. zeylonica* in Calcutta, Cunningham says that "the curious narrow tubular flowers of *Hamelia patens* are very special favourites, owing to the large store of nectar in their lower ends; and during the whole time that the shrubs are in flower they are sure to be alive with honey-suckers every morning. In this, and doubtless in many other cases, they seem to play a very important part in securing cross-fertilisation; for, by the help of a field-glass, one can clearly see that every time their bills are withdrawn from one tube and thrust into another, they are thickly smeared with golden pollen; and when flowers from which they have just been feeding are examined, the long oval stigmas will be found coated with adhering grains. In rifling the flowers, therefore, they confer a benefit on the plant, and do not play the part of mere robbers, like the great brown hornets, who share their liking for the nectar, but who, in order to reach it, drill holes through the corollas below the level at which the anthers lie.

"Curiously enough, they do not seem to care for the fluid in the corollas of the silk-cotton trees, which is so attractive to so many other kinds of birds that the trees, when in full bloom, become noisy and riotous taverns thronged with excited topers. The unopened flowers of *Hibiscus rosa-sinensis* are greatly frequented in the early morning on account of some attractive material to be found at the bases of the petals. Erythrinas are also very popular; the clusters of their bright red flowers are very often alive with a throng of clinging and fluttering little thieves; and an even more charming picture presents itself when the latter are busy among the deep green foliage and tufted crimson inflorescence of *Haematocephala Hodgsoni.*"

In his volume, *Some Indian Friends and Acquaintances*, Cunningham gives a long and charmingly written account of the habits of *A. zeylonica* in Calcutta, from which we would willingly quote at further length, did space permit, and we can only advise our readers to refer to Chapter XI of his book.

The Purple-rumped Sun-bird is the dominant species in Calcutta, but in Bihar our common species is the Purple Sun-bird, which is depicted in our plate. This is a less sociable bird, more often seen alone and not in company with others, as one sees *A. zeylonica*, but it is a much better songster than the latter, singing much like a canary. The cock bird in the breeding season is a truly gorgeous little creature, appearing a blue-black at a little distance ; but when seen at close quarters the colour is a metallic violet-blue or greenish, the colour changing according to the intensity and angle of the light on it so that it may appear shining blackish-purple or green or more often mauve.

"..............ceu nubibus arcus
Mille iacit varios adverso sole colores."

Under the base of his wings he carries a large tuft of mixed orange-red and yellow feathers, which is ordinarily concealed under the wings, but which projects when the bird is settled for repose and is displayed when courting. Like human bipeds, however, the Purple Sun-bird does not wear his wedding garments throughout the year, for after the nesting season is over he doffs them and assumes female plumage, retaining only a dark metallic violet streak from chin to abdomen as a mark of his sex. It may be added that there is a certain amount of difference of opinion as to whether the purple plumage of the male is or is not retained throughout the year, Messrs. Oates and Dewar contending that, when once assumed, it never changes ; but Finn, in an article in the *Journal of the Asiatic Society of Bengal* (Vol. LXVII, Part II, No. 1 ; 1898) settled this question, having noticed the change take place in a specimen which he kept, and which, when he got it, was mostly purple but by the first week of August was in non-breeding dress. We are inclined to agree with Finn as to the change. The female is greenish-brown above, rather bright yellow below with the tail

brown or blackish and the laterals narrowly tipped with white. The male especially is a most pugnacious little creature, not hesitating to attack other birds much larger than himself, and sometimes even scrabbling and tapping at windows, apparently attempting to assault his own reflection in the glass. The breeding season in Bihar is from February to May, the earliest nest taken being on 26th February and the latest on 30th May, and there are generally two or more broods in rapid succession, usually in the same nest. In Northern India, the laying season is later, in May and June, or as late as July or even August. In Southern India, eggs are to be found from January to June, but mostly in February to April. It breeds all over the Plains and to the summits of the Hills in Southern India and up to a height of about 5,000 feet in the Himalayas.

The nest is hung suspended from a twig or any convenient support and is composed of a very miscellaneous and heterogeneous mixture of materials beautifully woven together with the silkiest fibres and cobwebs, hair, fine grass, leaves, small pieces of dead wood, chips of bark, lichens, rags, scraps of paper, thorns, etc., all being made use of. The body of the nest is usually oval, with various scraps of material hanging below, while the apex of the oval is produced into a cone meeting the point of support. The nest is lined with silky-white seed-down, very neatly affixed to the interior. The entrance is a small oval or circular hole, about the centre of the nest, and in some cases, but not always, a small projecting cornice is constructed just above the entrance. On the side opposite to the entrance the wall of the nest, which is ready some days before the eggs are laid, is pushed out a little so as to give room for the tail of the sitting bird. This pushing out of the back of the nest is one of the last portions of the work, and the female may be seen going in and out to try the fit, over and over again. When sitting, the head of the bird is seen just peeping out of the entrance. The completed structure looks like anything but a nest and resembles a mass of dead leaves and rubbish caught in old spider's web. The rows of sticks which support edible and sweet peas in our gardens form a very favourite nesting-site for this bird in North Bihar, as these

sticks are in the ground during February and March, but the nest may be suspended almost anywhere, usually from the end of a branch of a bush or small tree, preferably a thorny one. It is usually placed between two and five feet from the ground but we have seen one as high up as forty feet. The nest shown in our plate, as will be seen, was hung on to a piece of wire netting. Suspended in this way it is tolerably safe from enemies. Two is the normal number of eggs laid, but occasionally there may be three, the eggs measuring about 16 by 11·5 mm., being dull white marked with various shades of brown.

This bird, with other Sun-birds, is protected throughout the whole year in Burma, Bombay and Bengal, and presumably in Mysore also, as it is certainly a " bird of song."

We have kept a specimen of the Purple-rumped Sun-bird in captivity for six months, feeding it on a mixture of sugar and *sattoo.*

Our plate gives a good idea of the Purple Sun-bird and its nest. To the left is seen a male in breeding plumage with its tufts displayed; the female is seen feeding a young bird whose beak is seen projecting from the nest; and below her, to the right, is a male in non-breeding plumage.

THE CO-OPERATIVE MOVEMENT AND POLITICS.

BY

R. B. EWBANK, I.C.S.,

Late Registrar, Co-operative Societies, Bombay Presidency.

THE traditional policy of co-operative societies in England has always been strict neutrality in politics. This tradition was accepted in India during the early years of the movement, and until recently has not been challenged. In 1915, the Committee on Co-operation advised that societies should be prohibited from interfering actively in political controversies, and some local Governments have given effect to their recommendation by a formal rule under the Co-operative Societies Act. This policy has not, however, been unanimously endorsed by co-operators, some of whom maintain that the movement ought not to be isolated from the main stream of public life in India, and that the State cannot at the present stage afford politically to ignore a system which has embraced and organized so many of the best representatives of classes, which are otherwise still disorganized and inarticulate. It has been suggested that the movement as a whole should seek direct representation on the Legislative Councils, either by the reservation of special seats for co-operative nominees or by devoting a portion of its funds and influence to the support of those candidates at the general elections who are pledged to support its special interests. Suggestions have also been thrown out that the privilege of enfranchisement should be extended to all members of the managing committees of efficient societies, or that certain societies of sufficient importance should be empowered to appoint delegates to vote on their behalf at the general elections. It has been urged

that co-operators should seek special representation on local bodies as well as on the Provincial and Imperial Councils. Opinion is deeply divided on these issues, and the leaders of the movement are still groping for principles on which to base their policy and to formulate their aims. The question is one which during the last four years has profoundly stirred co-operators in England, and is at the present moment the crux of a heated controversy amongst them. I have recently had opportunities of discussing it with prominent co-operators in Great Britain, and believe that their experiences in this matter cannot fail to be instructive to their fellow co-operators in India.

It was as far back as the sixties of the last century that English co-operators first burnt their fingers by meddling in politics. The Rochdale Equitable Pioneer Society began the trouble by actively supporting the movement in favour of the suffrage for working men. The Conservative members resented this and started a rival society working in the same area. A third society was founded by a group of independents who rejected alliance with either political party. The split ran right through North Lancashire, and more than a dozen Conservative and independent societies were started. However, the local leaders soon realized the futility of such internecine strife and its inconsistency with co-operative principles. A truce was patched up ; most of the new societies were gradually absorbed by amalgamation ; and neutrality in politics was accepted as an axiom of the movement.

The wisdom of this policy was not seriously challenged until Sir W. Maxwell, speaking as President of the Perth Co-operative Congress in 1897, restated the case for political action powerfully enough to induce the Congress to adopt unanimously the following resolution :—

> "That this Congress feels that the time has arrived for the direct representation of the co-operative movement in Parliament and other councils of the United Kingdom, and instructs the Co-operative Union, with the co-operation of the English and Scottish wholesale societies, to take steps for that purpose."

In accordance with this resolution a joint Parliamentary Committee was formed consisting of 12 representatives, four being elected by each of the bodies indicated. The Committee do not seem to have made any very earnest efforts to secure direct Parliamentary representation ; but they kept a keen eye on the proceedings of Parliament, and whenever the interests of the movement seemed to be threatened by any Parliamentary action, they bestirred themselves to interview Ministers and to canvass M.P.'s in favour of the co-operative point of view.

It is not denied that they were often successful in influencing legislation and administrative action, but it is generally believed that they would have exercised far more influence on Parliament, if it had not been well known that the co-operative movement, regarding itself as essentially non-political, wielded no weapon in the form of a vote either inside or outside the House, and would not bite if its bark were disregarded. Its blank cartridges were no match for the powerful artillery of the private trading interests.

At the Paisley Co-operative Congress in 1905, Mr. T. Tweddell, J. P., read a very striking paper advocating direct representation in Parliament. He maintained "that the interests, the freedom, the very existence of the movement depend upon Parliamentary sanction, and are amenable to the influence that Parliament wields ; that political action affects us too closely to permit of its being disregarded ; that indifference to political consideration is the surest way to invite attack and to court disaster ; that co-operation, itself one of the most hopeful forces that aim at social betterment, is imbued with democratic sentiment, is maintaining sympathetic relationships with trades-unionism and other working class combinations, and cannot help being impelled in the direction of political action, for the defence of its interests and the pursuit of its ideals." The deep impression that this able paper was calculated to make was marred by a weak conclusion. After exhorting his hearers to rise to a higher and truer conception of politics divorced from party and regarded simply as a science of human welfare, the reader ended by advising them to cease to be befooled by the existing political parties, to close their ranks as working men, and

to learn the blessed art of acting together, presumably in the bosom of the Labour Party. But the Congress resisted his logic and refused to commit itself to the entire programme of any political party.

The voices within the movement, advocating direct intervention in politics, were about this time strengthened by a new cry raised from outside by certain Labour leaders. The Labour Party felt the need of fortifying their position by an appeal to a wider circle than the small socialist and syndicalist element among the labouring classes, and invented a new slogan which speedily became fashionable—"The Fusion of Forces." This was the name under which a campaign was carried on to persuade the co-operative and trades-union organizations to join forces with the Labour Party and to share a common political platform. There is no room for doubt that the idea appealed to many co-operators, and, as the struggle between capital and labour has become more and more the central point of the political battle ground, round which all political combinations tend to group themselves, a feeling has been growing that the movement cannot remain aloof from a struggle which concerns its first principles so vitally. It was with minds confused and shaken by these new currents of ideas that co-operators entered the great war, and were gradually led, by practical experience of the State control of the necessaries of life, to the conclusion that the great system of production and distribution which they had so laboriously built up might be gravely imperilled, unless they took measures to compel the new Ministers to admit that their claims to recognition and special treatment were at least equal to those of their competitors.

Under the stress of war Government were compelled to introduce methods of rationing the chief necessaries of life on a national scale, and to improvise Ministries, Commissions, and Committees to control their production and distribution. The *personnel* of these controlling bodies was recruited partly from the permanent Civil Service and partly from leading business firms with special experience of the various commodities which were brought under control. At the outset practically no managers or experts connected with the great co-operative factories or distributive stores were offered posts

in the new Ministries. In Germany and France, the service of such men had been eagerly sought by the Government departments concerned, and a suspicion inevitably sprang up that in Great Britain they were being deliberately excluded under the influence of the vested interests, which had for some years shown open hostility to a movement which in 1917 included over $3\frac{1}{2}$ million members, and carried on an annual retail trade amounting to more than £120,000,000. Co-operative societies listened with misgivings to the clamour for a business Government, and feared that it might end in entrenching the great capitalist interests more firmly than ever in their hold on the administrative departments of State. Before long they began to feel that their fears had been well-grounded. They maintain that the recruiting tribunals were influenced to deal more rigorously with the staffs of co-operative shops than of private shops, on the ground that they were not a national necessity and paid no income-tax, and that in consequence of this several of their shops had to be closed down altogether. In one case a warrant was issued by a military officer directing a search of the premises of the Co-operative Wholesale Society, although no other business house in the city was similarly treated. The supply of sugar was confined by the controlling authorities to agencies acting prior to 1914, and they were guaranteed commission at the pre-war rate. This measure seemed designed to protect vested interests and prevented co-operative stores from being as useful to the public as they might have been. In some cases the supply of flour furnished to outside competitors was alleged to be better than that assigned to co-operative stores, with the result that their trade in flour almost disappeared. The supply of wheat to the Scottish Wholesale Society, which claims to be the biggest miller in Scotland, was so unsatisfactory that the miners decided to take an off-day as a protest against the quality of the bread. Similar grievances are mentioned with regard to butter, coal, tea, seeds, petrol and shipping.

The conviction spread that co-operative shops were being victimised in the interests of private traders, and this feeling was reinforced by fears regarding their liability to income-tax and excess

profits tax. Rumours had been set on foot that co-operative societies were undermining and ruining private trade owing to their exemption from income-tax and were evading their fair share of the national burdens. Although Government showed no signs of yielding to this agitation, co-operators felt nervous and thought it advisable to protect themselves by organizing a counter-campaign. In the matter of the excess profits tax they had a real grievance. Although it had been officially admitted by the Exchequer that the dividends paid to their members by co-operative societies were in the nature not of profits but of discount or saving, Mr. McKenna brought co-operative societies within the operation of the excess profits duty, imposed under the Act of December 1915. The policy of treating a co-operative society, except in so far as it dealt with non-members, in the same category as a war profiteer, roused great resentment, and some of the larger societies actually defied Government and refused to pay the tax.

With grievances like these rankling in their minds and with a sense that the many great sacrifices which their societies had undoubtedly made in the cause of the war were not properly appreciated, co-operators met for their annual Congress at Swansea in 1917, and decided that their complaints should be brought to the immediate notice of the Government, and that steps should be taken to secure the representation of co-operators in Parliament. Acting on these resolutions, the Parliamentary Committee submitted to the Prime Minister their considered suggestions on food control, sugar distribution and the use of co-operative organizations by the State, and requested him to receive a deputation. After some delay, they were informed by the Prime Minister's secretary that, owing to his many and pressing engagements, Mr. Lloyd George was quite unable at that time to arrange a meeting with the Parliamentary Committee of the Co-operative Congress. Co-operators were not at the moment in a mood to accept a reply of this sort quietly, and it was decided to convene a Special Co-operative National Emergency Conference at Westminster in October 1917 to consider what should be their next step. The proceedings of this Conference were marked by unusual heat and bitterness.

Resolutions were passed recording indignation at the way in which the Prime Minister had treated British co-operators, and pledging themselves to organize to the fullest extent their political power in order to compel the Government of the day to recognize their special economic position. The Conference emphatically protested against the persistent neglect of Government to use their experience and resources for national purposes and to grant them adequate representation on the new administrative and advisory authorities that had been created. It recorded its conviction that the imposition of the excess profits duty upon co-operators was an absolute negation of justice and called for its immediate repeal. It maintained that it was the intention of the Government again to inquire into the position of co-operative societies with regard to income-tax after the war, and urged all societies to pursue a campaign of opposition to this change with the utmost vigilance. It expressed its strong objection to the constitution of the tribunals under the Military Service Acts, and to the inadequate safeguards against the misuse of their powers. It approved a scheme for bringing about closer unity between the co-operative and trades-union movements, and another scheme for securing co-operative representation in Parliament and on local, municipal, and administrative bodies.

Immediately after the holding of this Conference, the Prime Minister found time to receive the proposed deputation, and in company with the Food Controller, Lord Rhondda, and the Rt. Hon. George Barnes, M.P., gave a very sympathetic hearing to the grievances which they put forward. He brushed aside many of their suspicions of sinister motives on the part of Government as mere hallucinations, and recapitulated the measures which had been taken to secure that representatives of co-operative societies should be placed on the various committees of control. He stated definitely that Government had no intention of bringing co-operative societies under the Income Tax Act, and explained that the excess profits tax, as originally imposed, had recently been modified so as to meet the complaints of co-operators. From the date of that interview onwards the grievances of co-operative societies against the various controls seem to have gradually subsided.

But their determination to seek direct representation in Parliament remained unaltered. At the General Election of December 1918, 10 co-operative candidates stood for election. Only one of these, Mr. A. E. Waterson of Kettering, a local Labour politician, was actually returned. His platform was much the same as that of the official Labour Party ; but the following paragraphs in his manifesto refer specially to co-operation :—

"1. To safeguard effectually the interests of voluntary co-operation, to resist any legislative or administrative inequality which would hamper its progress."

"2. That eventually the processes of production, distribution and exchange (including the land) shall be organized on co-operative lines in the interests of the whole community."

"3. That the profiteering of private speculators and the trading community shall be eliminated by legislative or administrative action."

"4. That in order to facilitate the development of trade, commerce, and manufacture after the war, the Government shall establish a national credit bank to assist local authorities, co-operative societies, and others to finance their new undertakings as required."

Mr. H. J. May, the well-known Secretary of the Parliamentary Committee and himself one of the defeated candidates, explained to me that while members elected on the co-operative ticket were not definitely committed to any party and were willing to enter into any combination which would best serve their purposes, it might be assumed that they would normally work in the closest harmony with the Labour Party.

Whether this venture into the political arena will be permanently maintained by co-operators remains to be seen. Much will probably depend on the issue of the next polls and on the success or failure in the House of their earliest representatives. A strong party within the movement, led by Mr. E. O. Greening, one of the most respected members of the Co-operative Union, are strongly opposed to the departure. They know how few members usually take the trouble to attend annual general meetings (*e.g.*, only about

300 came to the last general meeting of the Woolwich Arsenal Society which comprises more than 80,000 members), and how easy it is for enthusiastic extremists to arm themselves with bundles of proxies and to carry all before them. They already see signs of reaction and point to the fate which has overtaken the Managing Committees of the great Sheffield and Plymouth Societies, who dabbled too freely in politics to please the members and have recently failed to secure re-election. They note that the numbers of societies contributing funds to the political campaign was less in 1919 than in 1918. Now that the friction and inconvenience caused by the various war controls have disappeared, they gravely doubt whether co-operators as a body will think it wise to persist in a policy into which they were stampeded in a fit of exasperation. In the long run these sceptics may prove right; but my own forecast, based on conversation with such co-operators as I have met and on the articles appearing in the co-operative journals, is that the trend of opinion is on the whole in favour of the new policy, and that it will not be abandoned until it has been given a full trial.

The first point in this history of events, which may be commended to the notice of Indian co-operators, is the persistence with which the policy of neutrality was maintained in spite of the blandishments of both the Liberal and Labour Parties throughout two generations, and the reluctance with which it was finally deserted. Co-operators in Great Britain have never held that they should not proclaim their views and exert their influence on individual political questions. The Sugar Convention, the land system, the Factory Acts, the fiscal question, and education have frequently been discussed at their conferences with vigour and vehemence. But they have always considered that their movement was commercial, social and moral, but essentially not political, and that there were large regions of politics, *e.g.*, foreign, naval and military politics, with which they had no direct concern. To attempt to link their organization to any political party or to adopt a corporate policy regarding the great national issues, in which co-operators as such were not directly interested, seemed to them certain to lead to dissension and to make for the disruption of a movement which was founded

on the principle of common action for specific common objects. They were unable to admit the justice of utilizing funds which had been collected for definite co-operative purposes, in furthering political aims with which a large number of the members were not in sympathy. Their contention was that members, who wished to bring their influence to bear on questions of general politics, should do so in their capacity as private citizens and electors and not as co-operators.

The next point to notice is that they only abandoned their traditional policy under the stimulus of concrete disabilities which were handicapping their business and which they believed themselves unable to remedy without direct political pressure. They were not seeking any preferential treatment for themselves. But they insisted that they were entitled to equality of treatment with other trading agencies, and they suspected that under a democratic Government, which is always more or less susceptible to pressure from outside, they were being covertly attacked by hostile interests plotting to undermine their prosperity. They claim to have gone into politics not as a measure of attack in order to gain further advantages for themselves or to make themselves felt and feared on a larger scale, but as a measure of defence against an insidious attack originated by their enemies.

Lastly, it may be observed that co-operators have concentrated their efforts on securing political power by means of direct representation in Parliament, and that they are practically agreed that their representatives should vote and act with the Labour Party. The corresponding action in India would be the return of co-operative candidates by general district constituencies, since the prospect of Government reserving special seats in the Councils for co-operators is exceedingly remote. In Great Britain co-operation has developed as a great consumers' movement, and is composed mainly of industrial employees who have united in order to cheapen the necessaries of life and make their wages go further. It comprises for the most part a single class with more or less uniform political ideals. Their congresses consist only of delegates of this class, and no longer find room for individual sympathisers from the

upper classes of the type of Vansittart Neale. In India the movement embraces three distinct classes : the producers, including all agriculturalists; the consumers, consisting mainly of the industrial populace; and the bourgeoisie, represented, for example, by the great caste societies and the central banks as at present constituted. It is not yet clear what party divisions will manifest themselves in the new Legislative Councils, nor whether it will be possible for elements so diverse as those taking part in co-operative work to agree on a common political programme. Any movement to ally the organization to any particular political party would probably give rise to acuter differences of opinion in India than in England.

The question whether co-operators should take part in politics has been treated in this paper as a co-operative and not as a political problem. If Government, in lack of any other constituency representing the labouring classes, were to invite co-operators as such to accept some form of enfranchisement, that would create an entirely new situation. But as matters stand at present, the British example seems to teach that co-operators should hesitate to abandon political neutrality until they are driven to it by definite grievances arising from political or administrative action, and until they are sure that the representations submitted by them to the proper authorities are not being dealt with on their merits.

In India societies occupy at present a distinctly privileged position under the special protection of Government. They have much to lose and it behoves them to tread delicately. At the same time on particular political questions, especially those in which their own interests are directly affected, it seems clear that they have a right to make themselves heard and that their views might be of great value both to Government and the public. It would probably be inadvisable, for the sake of securing their general neutrality on the wider issues of party politics, to debar individual societies, or any organization capable of representing the movement as a whole, from discussing such questions and placing their considered conclusions before Government, the Legislative Councils, or the public.

THE IMPROVEMENT OF AGRICULTURE IN BIHAR.*

BY

A. C. DOBBS, B.A.,

Director of Agriculture, Bihar and Orissa.

HAVING been asked to contribute a paper to this Conference, I should like to advocate the study of agriculture by Bihari students, when their more academic studies are over, not necessarily as a profession, but at any rate as a subject about which it is essential that the educated youth of Bihar, on whose judgment as voters so much responsibility will shortly be thrown, should think deeply in proportion to its importance.

On that importance it is hardly necessary to insist. It has been brought home to us all by the increased prices of food grains and of cotton cloth, due partly to the extensive failure of crops in 1918, and partly to the exposure by the realities of war of the artificial nature of the value attached to the precious metals in which contracts other than those relating to agriculture are usually discharged. The rupee does not buy half as much as it did, and the agriculturist whose income is not measured in rupees has some compensation for an occasional crop failure.

I hope, therefore, to be able to enlist the interest of at least some of those present who no doubt intend to be Bachelors and Masters of Arts, in this aspect of agriculture—as an art which every educated man who draws income from land should study.

Agriculture is indeed one of the oldest of the arts, and, if we extend the meaning of the word to include the whole art of reaping Nature's harvest of food, it is the oldest art of all.

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* A paper read at the Fifteenth Bihari Students' Conference held in October 1920.

And in this fact lies the explanation of one of the most disconcerting and difficult problems with which those who try to improve agriculture are faced. For, being based on an inherited tradition, almost amounting to instinct, of the uses of the natural resources of each locality for the production of food, and on a compelling interest in the bare maintenance of life, the art of merely producing food can be carried on with the minimum of material equipment and with the greatest possible economy by an indigenous agricultural population on the borderline of starvation. An outsider attempting to grow the same products with hired labour is not competing on equal terms, and almost invariably fails to make agriculture pay. He has a less intimate knowledge of the plants and animals that he is dealing with and of the effects of soil and climate on them, and the labourers he employs have no direct interest in the results of their labour; they will, in fact, where land is plentiful, commonly work for hire only after finishing the necessary minimum of work on their own land.

In a country of labouring cultivators we are, therefore, confronted with the initial problem that the greater the skill of the cultivator and the better his practice in the matter of using good seed, manure and implements, the more difficult it is to make agriculture pay for the application of outside intelligence, and the more immediately costly becomes any indulgence of the natural desire of many educated men to "take up" agriculture. It is only by the introduction of new factors beyond the scope of the labouring cultivator that an outsider can hope to make agriculture pay; and to do this on the scale necessary to make what an educated man considers a decent living involves the risk of a considerable amount of capital.

The work of agricultural improvement, therefore, falls into two distinct and almost opposed branches: firstly, the discovery of more economical seeds, manures, and implements for the man who works on his own land—which may be called purely philanthropic work; and, secondly, the elaboration of profitable systems of utilizing any peculiar local advantages, by the introduction of new factors beyond the control of the labouring cultivator. And while the Agricultural Department's work has been chiefly along the former line, it is the

latter to which I wish to direct the particular attention of Bihari students.

Apart from the few retired business men who take up agriculture as a hobby, and are unlikely to make it pay unless they can find some existing model to copy, it may, I think, be assumed that most of the educated men who are interested in agriculture, among whom I hope many of those at this Conference may be included, are, or will be, landowners on a larger or smaller scale, who have an annual income from land, and possibly some outside capital. The control of this income or capital is the most obvious outside factor which, if, but only if, skilfully used, on a carefully planned and tested system, should enable any of you to improve the agriculture of your locality.

Instances of such systems of agricultural improvement by judicious expenditure will occur to all of you. Perhaps, the most important, at any rate in South Bihar, is the system of 'pines' and 'ahars' by which enormous areas are protected against the effect of a shortage of rain at this season. The reward of such permanent capital improvements is, however, for the most part reaped in the form of increased rent; I can think of no improvement in system, introduced by Bihari landowners, which produces increased profits on working capital,—as, for instance, the use of larger bullocks with suitable implements, such as are used on Government farms, which enables a man to do two or three times as much work in a day without necessarily increasing his wages. The breeding of larger cattle and the use of larger implements is one of the directions in which a solution may be sought of the problem of making agriculture pay for increased attention on the part of educated men. There are many others, but they all have this in common, that it requires a considerable amount of initial experimental work based on a knowledge of the local conditions to develop a new system to the point at which it can be profitably adopted on a large scale.

On the other hand, the ultimate profit may be very great. The Agricultural Department has, for instance, shown that it is possible, by a combination of drainage in the monsoon with the ordinary irrigation of sugarcane at other seasons, to produce 6,400 lb. of *gur* per acre, on a large scale at comparatively little more expense

than is usually incurred in the production of one-third of this quantity. Drainage is not always possible in Bihar, but there are large areas in South Bihar where there should be no difficulty. This again is only an instance. What I should like to impress on this Conference is that the way to any considerable improvement in the agriculture of Bihar lies through the direct application of intelligence to agriculture and horticulture on a small scale by educated men who have the opportunity to study the art on their own land without any immediate necessity of making a profit. It is not only unnecessary, but impossible, to learn agriculture at a school or college ; each man must study it for himself on his own land. On the other hand, science can give a good deal of help, and the Agricultural Department, though unfortunately unable at present, owing to a partial suspension of its work during the war, to give very much practical assistance, can always make suggestions for experiments which, if not always successful under new conditions, will at any rate prove interesting and instructive ; and which may point the way to simple improvements adapted to the locality, which can be worked out on a small scale at comparatively small cost, and the adoption of which on a large scale may bring copious reward for the small amount of drudgery incidental to what is after all, to those who love the ever changing face of Nature, a most interesting and fascinating study.

If then any of those Biharis, who may, perhaps hitherto, have regarded themselves as only temporarily students, are prepared to continue their studies on their own land at home, I hope they will get into touch with the Agricultural Department which is always prepared to help, to the best of its ability, those who are actually superintending the cultivation of their own land.

A NEW SOIL SAMPLER.

BY

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Agricultural Chemist to Government, Punjab;

AND

MUKAND LAL MEHTA, L.AG.,
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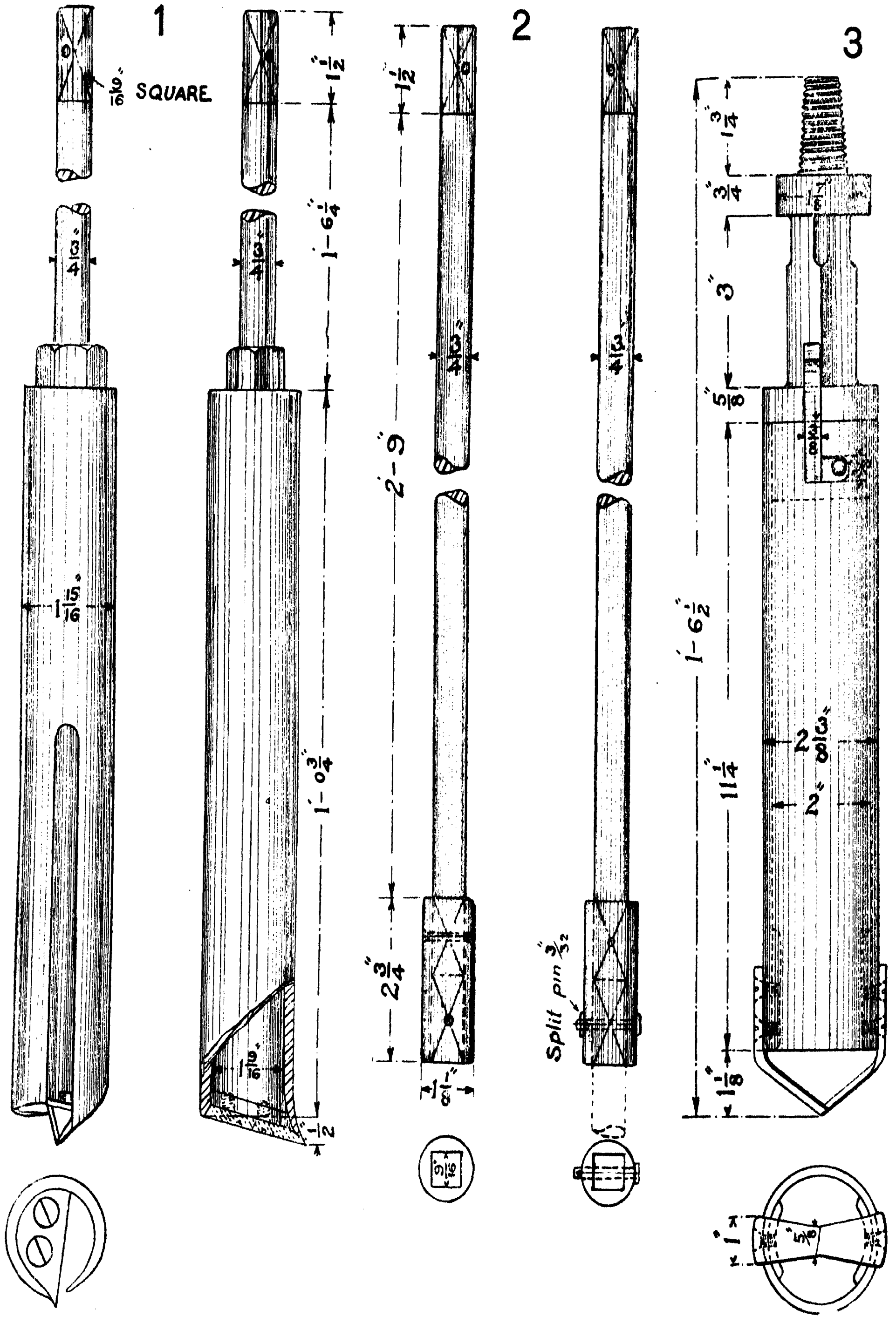
FOR the analysis of soil and the investigation of its moisture content, one of the greatest difficulties is to obtain a truly representative sample of the soil under investigation. A great variety of instruments has been described and some are in the market. The success which has been met with in a type which has been evolved at Lyallpur (Plate X), mainly with the object of taking deep samples for moisture investigations, together with the fact that it can be easily made by any intelligent *mistri*, leads us to give a description of it in the hope that it will prove useful to other workers. The main advantages which have been gained by the use of this instrument are—

(1) the rapidity of working,
(2) ease by which sampling may be pushed to a depth of as great as 12 feet,
(3) the fact that it is equally efficient in light sandy soil and the hardest clays, and
(4) the fact that no heating of the soil sample, due to grinding, takes place, which would cause an error in moisture determinations.

The drawings reproduced in Plates XI and XII will make any lengthy description of the instrument unnecessary. The auger can, of course, be made of any suitable size, preferably of steel. At the

A NEW SOIL SAMPLER.



A NEW SOIL SAMPLER.

mouth of the auger, a blade is placed in an oblique position which slightly projects beyond the diameter of the tube. The blade is removable and can consequently be sharpened. The advisability of allowing a slight projection of the cutting knife has been found in the fact that the hole so cut being larger than the diameter of the tube presents no difficulties in reinserting the auger after removing the sample. A slot is cut in the side of the tube, and this allows of the removal of a heavy soil by means of a spatula.

Fig. 1 on Plate XII shows a weight which can be placed at the top of the boring rod when difficulty is experienced in driving an auger through a very hard soil. It may be mentioned that it is very infrequently, and only at considerable depths, that there is any necessity to use this attachment.

Plate XII, fig. 2 shows details of a board which has been found advisable to use in deep borings, the object of which is to keep the direction truly vertical. The board is pegged down to the soil by four large iron pegs; by means of sliding shutters, the boring rod is enclosed by a bearing collar which will keep the rod perfectly straight.

With this instrument for ordinary surface sampling, *i.e.*, 1st and 2nd 9 inches of the soil, it is an easy matter to take as many as 250 samples in dry soil spread over an area of 25 acres in a working day of eight hours with only a pair of labourers. This is a tremendous improvement on the performance which can be got with the borer described by Leather (*Memoirs of the Department of Agriculture in India, Chemical Series*, Vol. I, Nos. 6 and 10), which is still in use in many parts of India. As an example of work under the most difficult conditions, it may be mentioned that it was found possible to sample to a depth of 11 feet in six separate places in the very hard soil met with at the Ganji Bar Experimental Station and spaced over an area of more than a square mile. This was done with the help of four labourers in an eight-hour day. The most unintelligent labourer can be trained to use the instrument in a space of about half an hour.

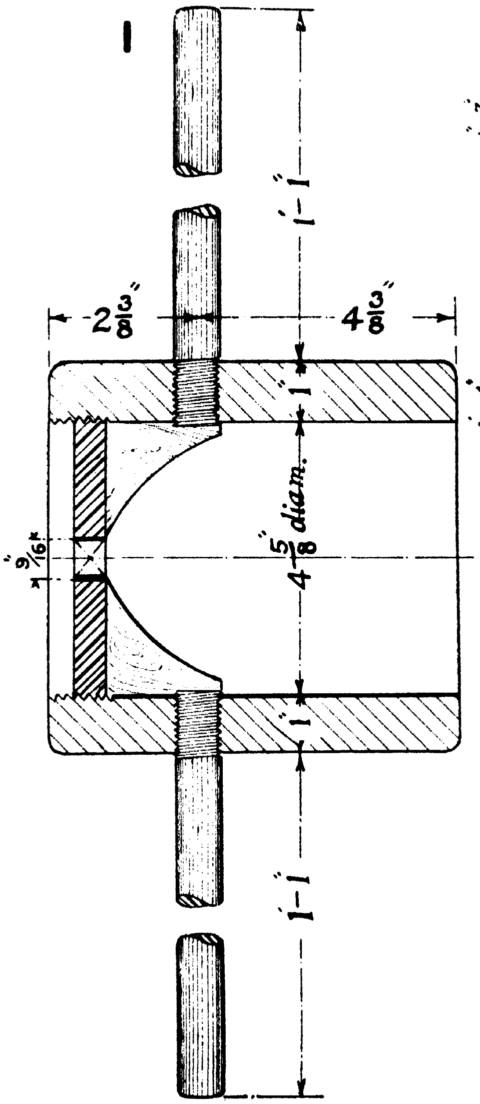
In connection with the work on the movement of soil moisture which is being conducted at Lyallpur, it has been found that the

experimental error involved in moisture determinations of samples derived from vertical borings is very considerable. A method has consequently been perfected by which horizontal samples are taken from an observation well. The observation well is cheaply constructed by lining a *katcha* well with a trellis of bamboo which is kept in place by wooden braces. For the purpose of taking samples, the sampling tool was somewhat modified.

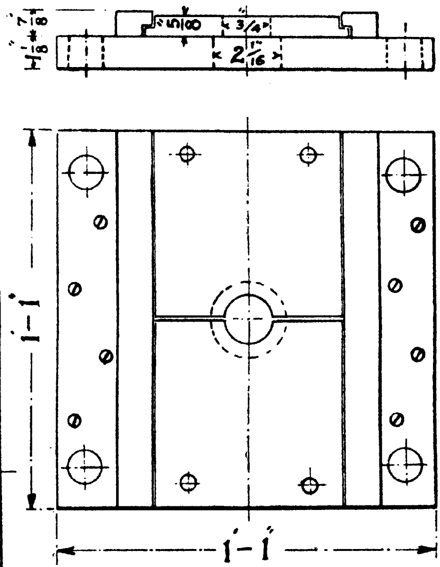
Fig. 3 on Plate XI shows the cutting tool. It is composed of a steel tube on which is rivetted a knife edge bent into the shape of a V. The tube can be fitted on to the socket by means of a slot and pin attachment, and is securely locked in place by means of a spring. The tool is then affixed by means of a conical thread to a ratchet drill which is placed diagonally across the well. By this means it is possible to take samples every 6 inches to a distance of 6 feet from the side of the well in the space of about three hours. After a distance of about a foot and a half, it is found that the moisture content of the samples becomes constant to within about 2·5 per cent. on the total moisture content. The following table shows the actual results obtained in one such boring which was made in a direction parallel to an irrigation channel and at a distance of about 8 feet from it. The error involved includes errors due to lack of uniformity in the soil and irregularity in the cross-section of the channel.

Depth	Moisture content	Deviation from mean
0″–6″	11·70	....
6″–12″	12·02	....
1′ 0″–1′ 6″	12·22	0·31
1′ 6″–2′ 0″	12·08	0·45
2′ 0″–2′ 6″	12·17	0·36
2′ 6″–3′ 0″	12·38	0·15
3′ 0″–3′ 6″	12·45	0·08
3′ 6″–4′ 0″	13·04	0·51
4′ 0″–4′ 6″	12·27	0·26
4′ 6″–5′ 0″	12·67	0·14
5′ 0″–5′ 6″	12·87	0·34
5′ 6″–6′ 0″	13·14	0·61
Mean ..	12·53	0·321
VARIATION PER CENT. ..	..	2·5

1



2



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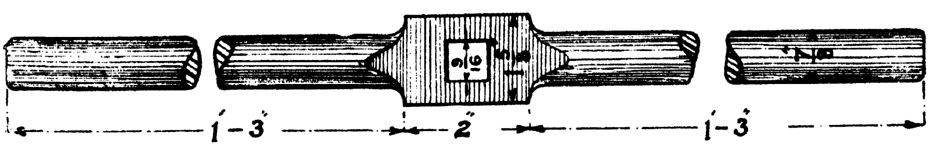

A NEW SOIL SAMPLER.

This method, therefore, allows of an accurate determination of the moisture content of the soil in a horizontal stratum at any depth which can be attained by the observation well. The cost of the ordinary borer first described is not more than Rs. 25. The weight of the borer excluding the weight, which is only seldom used for deep borings, is only 12½ seers.

EXPERIMENTS WITH CASTOR SEED CONDUCTED AT SABOUR.

BY

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THE importance of all oils has been greatly emphasized during the late war. Of all vegetable oils castor oil is perhaps the one the demand for which is most likely to increase. Originally used as an illuminant in the days before the introduction of the mineral oils, its use has now completely changed to that of one of the most valuable lubricants known. Attempts have therefore been made to determine whether by chemical selection it is possible to improve the race of castor from the point of view of its oil-yielding properties.

The main difficulty in the way of such a selection appeared to lie in the fact that the castor plant, with its separate male and female flowers, was much more likely to be subject to cross-fertilization than a plant whose flowers were hermaphrodite. In consequence the investigation, although it had appealed to the writer for many years, was left alone, as being probably of only academic value. In 1918, however, an article appeared in the *Journal of Heredity* (Vol. IX (1918), p. 198) in which it was stated that, contrary to expectation, castor plants grown in America had not been found very subject to cross-fertilization. In consequence an attempt was made to survey the different types obtained from various parts of Bihar. A number of types were sent in by different district inspectors, and were examined for oil-content in the writer's laboratory after drying. Remarkable differences in oil-content on seed were observed from these different types, of

which 75 were isolated from seed characters, by courtesy of the Assistant Economic Botanist, Mr. A. C. Ghosh. This oil-content, as estimated by ether extraction, varied from as low as 21·8 per cent. to as high as 58·8 per cent. on the whole seed. Such differences appeared very striking, and selections were made and planted of seeds of very low and of very high oil-content. Of the 'low' collections, no type had an oil-content of more than 40 per cent. and the average of 14 selections was 32·9 per cent. oil on seed. Of the 'high' collections, no type contained under 50 per cent. of oil and the average oil-content of 13 selections was 52·8 per cent. These types on growing were found to be very impure. This was only to be expected as the crops have never been grown with any attempt to keep different varieties separate. It was, however, to be expected that the first generations of plants from seed with oil-content as widely varying as the above would also, on the average, show very large divergences which, even if they were less than those of their parents, would still be very large. Of these selections only 12 of each kind, 'high' and 'low,' actually grew, whilst actually the average oil-content of the seed of plants from 'high' seed was 49·3 per cent., and that of seed from 'low' seed was 50·6 per cent. Results such as these could not be expected to have occurred as a result of cross-fertilization, nor to have been due to mixed varieties, and it was assumed that the great differences, originally observed in oil-content in the seed of these varieties, may have been observed owing to the different conditions under which the plants were grown. At any rate it is obvious that selection of seeds at random from different localities, in which the seed may have been grown under very different conditions, is not likely to be of much use.

Fresh selections were therefore made from the highest and lowest yielders of the 1919 crop. In this crop, the plots of which were grown under uniform conditions at Sabour, the differences between high and low yielders were not so great. Fifteen parents of low oil-content were taken and twenty of high oil-content. Of the descendants of the fifteen 'low' plants only 10 plots showed good growth. It would therefore be better to consider only these ten,

as it is possible that the state of growth of the plant may have an effect on the oil-content of the seed. Nine of the twenty 'high' plots should probably also be eliminated, as they were badly affected by insect attack, and, in consequence, the flowers and seed were probably abnormal. In fact, the amount of seed produced was very small, and in every case showed an oil-content below the average. The mean of the 11 good plots was 49·6 per cent. for descendants of parents whose mean was 54·2 per cent. The mean of the 10 well grown 'low' plots was 48·6 per cent. from parents whose mean was 42·5 per cent.

These results were found to differ very little from those obtained by taking the mean of all the plots, whether well or ill grown. In this case the mean of the 20 'high' parents was 54·8 per cent. and of their descendants 47·8 per cent. The mean of the 15 'low' parents was 44·1 per cent. and of their descendants 47·3 per cent. There appear, therefore, to be strong indications that in the majority of cases the plants do not transmit a high or low oil-content for even one generation, but that both 'high' and 'low' seeds give plants which, in nearly every case, give a seed near the mean oil-content, which lies somewhere close to 49 per cent. when the plants are healthy, and a little lower when the reverse is the case. It will be seen moreover that the inclusion of the unhealthy plots has in each case, as was to be expected, lowered the mean oil-content of seed observed. Out of the whole series, however, two appear to have kept pure as regards high oil-content for more than one generation. This will be shown by the following table :—

Plot No.	Original analysis	1st generation	2nd generation	Weight of seed in ounces
26/19	51·9	52·4 green	3 distinct varieties each high in oil— Green .. 50·0 Purple A .. 50·4 " B .. 51·3	 28 10 ¼
34/19	58·8	57·0 dull purple	Two distinct varieties— Purple A .. 52·8 Purplish green B .. 52·8	 15 22½

In addition, a plot has been observed which shows a splitting-up into different varieties which differ in oil-yielding as well as in ordinary botanical characters. This is shown by the following table :—

Plot No.	Original analysis	1st generation	2nd generation	Weight of seed in ounces
75/19	54·7	54·9 green	Four distinct varieties—	
			Green A .. 51·8	4
			,, B .. 50·6	12
			Purple A .. 46·6	$\frac{1}{2}$
			,, B .. 50·4	$\frac{1}{2}$

It will be noted that in this last instance the low-yielding variety is only present in very small quantity, and may possibly be due to a first cross as the original parent was green. Observations on these three varieties will be continued.

The method used in these analyses was that of extraction of the dried seed with ether. This method, naturally, shows a higher percentage of oil than could possibly be obtained by the oil-presses used in this country. The results, however, may be taken to give a good comparison between different varieties, and give a good idea of what could be obtained commercially by the modern method of extraction by solvents such as petroleum ether or carbon tetrachloride. There were great practical difficulties in the way of extraction of more than a small quantity of seed, and in consequence it is necessary to examine how such a small sample will indicate the composition of the main bulk. For this purpose a number of samples of seed obtained from botanically pure, or nearly pure, varieties of *bhadoi* castor were kindly placed at my disposal by Mr. A. C. Ghosh, Assistant Economic Botanist. The analysis of 15 samples from a bulk collection of one variety showed last year a standard deviation, from the mean, of ± 1·04 per cent., the mean being 49·5 per cent. Other analyses have been made this year, taking selections from plant to plant in each of these fairly pure varieties, and such analyses in each case show a standard deviation, from the mean of the series, of about ± 1·5 per cent., th emean varying from 47·6 per cent. in the lowest case to 50·9 per cent. in the highest. From these

observations we may calculate that the probable error in the oil determination of a single sample of any one variety will be about ±1·0 per cent. of the weight of the seed. This is the case when the crop is fairly evenly grown, and when the seeds appear to be properly filled out. Greater variations have been found to occur in a crop of seed which does not appear to be fully developed. As an example of the differences in magnitude of the variations which occur in a pure crop which is grown under different conditions, we may take a castor which was selected both for field characters and oil-content in 1918. This variety was isolated among others at Sabour by the Professor of Agriculture, Mr. S. N. Sil, and was finally selected as the result of analysis in the writer's laboratory. The original analysis of this variety, known as *pachka*, showed an oil-content on whole seed of 52·1 per cent. in 1918. The variety has been continued in 1919 and on to this season. A single analysis was done on this variety sown both in the *rabi* and *bhadoi* seasons. The *bhadoi* sample, which gave better developed seeds than the *rabi* grown plant, showed an oil-content of 56·2 per cent. of oil on seed, and the *rabi* sample showed 53·6 per cent. The variety therefore appeared to be keeping up its reputation for high oil yield, and in consequence ten samples were analysed of the seed grown in the *rabi* and *bhadoi* seasons, respectively. The *rabi* grown crop showed a mean of 52·3 per cent. with a standard deviation of ± 2·0 per cent., while the *bhadoi* grown crop showed an extraordinary evenness in the samples. The mean of the ten samples of this latter was 54·4 per cent. and the standard deviation only ±0·7 per cent. As has been already mentioned, the *bhadoi* sown seeds gave a far better developed crop of seed than those sown in the *rabi* season, and it is probable, from the large standard deviation observed in the latter, that the effect of different conditions of growth may be strongly marked in the seed obtained from each plant. Reference has already been made above to the possibility of this phenomenon, and this result would appear to confirm this reasonable expectation. It would, moreover, almost appear from the above results that variations in agricultural treatment may possibly have more effect on the oil-yield of the crop than actual chemical selection. As the

result, therefore, of a considerable amount of work, a few varieties have been selected which appear to be richer in oil than others, and which maintain a mean oil-content greater than 49·5 per cent. which may be taken as the mean of all the types tested here. The improvement, however, is not as marked as was hoped, the greatest improvement observed above the general mean this year being just under 5 per cent. in the case of the *bhadoi pachka*, while the *rabi pachka* only showed an improvement of about 3 per cent.

A NOTE ON THE IMPORTANCE OF THE GENUS "HABRONEMA" AS AN ECONOMIC FACTOR AMONGST THE EQUIDÆ OF THE PUNJAB AND THE NORTH-WEST FRONTIER PROVINCE.

BY

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IN Fleming's translation of Neumann's Parasitology, "Spiroptera" or, to give them their more modern name, "Habronema" are stated to have slight, if any, pathogenic significance. Anyone who has had experience of the condition and has seen the large suppurating tumours produced by *H. Megastoma* in the pyloric region of the stomach, and the occasional ulceration, inflammation and congestion caused by *H. Muscæ* and *H. Microstoma* in the cardiac portions of that organ, knows that this statement is utterly at variance with the facts of the case.

This disease in recent years has received a certain amount of attention in Australia and America, and is rightly blamed as being the cause of much loss in both countries.

During the past year the writer has had many opportunities of examining the stomachs of horses and mules which have been destroyed for chronic debility from various Stations and Remount Depôts in the Punjab and the North-West Frontier Province.

In every case the stomach was the seat of serious lesions due to the ravages of one or all species of the *Habronema.*

In one case the writer was asked to give his opinion as to the persistent debility shown by a batch of fifty Tibetan mules. The R. A. V. C. authorities concerned kindly placed several old debilitated cases at his disposal. Post-mortems proved that in every case the condition was due to Habronemiasis.

The condition may be recognized by the tumours of various sizes in the case of *H. Megastoma*, and by the large numbers of tiny thread-like worms lying on the mucous membrane of the cardiac portion of the stomach in the case of *H. Muscæ* and *H. Microstoma.*

These are more easily seen if the ingesta is removed from the stomach and the organ placed in a vessel of water, when the parasites can be readily seen floating throughout the liquid.

The life-history of the parasites has been worked out by Bull, Van Sacegham and others, and is briefly as follows :—

The eggs produced by the female *Habronema* pass out in the fæces and are ingested by the fly maggot. These eventually make their way to the thorax and proboscis of the mature fly, and it is supposed that the horse, by ingesting infected flies either in his food or drinking water, infects himself, and thus completes the cycle. *H. Muscæ* and *H. Megastoma* have as their intermediate host the common house fly—*Musca domestica*, whilst *H. Microstoma* develops in the stable fly—*Stomoxys irritans.*

The fly can only become infected as a larva, not as a nymph.

The adult *H. Megastoma* is found enclosed in tumours and seems for preference to select as a site the pyloric portion of the stomach although the lesions may be found in any part of the organ.

These tumours are generally conical in shape and vary in size from that of a small pea to that of a hen's egg. The tumour is usually full of hard inspissated pus, and a number of worms can generally be seen protruding from a small opening at the apex of the cone and waving in the lumen of the stomach. In some cases there is no opening. It can readily be understood that the portion of the stomach thus affected ceases to function. This species is the most harmful of the *Habronema.*

H. Microstoma and *H. Muscæ* lie loose on the mucous membrane of the cardiac portion of the stomach, and may cause an acute

inflammation and congestion. They do not seem to affect the pyloric portion of the organ. *H. Muscæ* is probably the least harmful of the three species.

Lewis and Seddon, Bull and Van Sacegham have proved that the disease known as "Habronemic Granuloma" is caused by the larvæ of these parasites, *H. Microstoma*, in all probability, being the species chiefly concerned. The condition known in India as "Bursatee", and believed by Lingard to be due to Filariasis, is probably due to the larvæ of the *Habronema*. When one considers the fly population of India and the construction and sanitation of the lines and stables of the various Army Units and Breeding Studs, but more so of the civilian population, and the opportunities thus afforded for the spread of any disease from manure in which the fly is likely to act as a carrier, it is quite obvious that Habronemiasis is likely to be responsible for many, if not most, of the chronic cases of debility which must annually cost the Army and the country very large sums of money. Add "Habronemic Granuloma" (Bursatee) and "Habronemic Conjunctivitis", and the importance of the prevention and eradication of this all too often unrecognized condition is at once evident.

Prevention. Eradication of flies as far as possible, thorough cleanliness and strict sanitation as regards manure are the essentials. There are various methods for dealing with manure. Robaud's method, *i.e.*, burying the fresh dung daily inside a heap of fermenting manure and thus destroying the larvæ of the *Habronema* and the fly maggot, is probably the most simple. However, that is a point that can best be decided by the authorities concerned.

The early isolation of all debility cases, thorough destruction of the excreta when possible, and dosage with a reliable vermifuge (*see* treatment) should be insisted upon as a routine measure.

Treatment. The work of Maurice Hall and others has shown the great value of *Ol. chenopodii* as a vermifuge. This drug either alone or in conjunction with chloroform, followed by linseed oil and turpentine, might be tried with advantage.

It should prove efficient against *H. Muscæ* and *H. Microstoma,* and it might be effective against *H. Megastoma.* Carbon bisulphide

whose value as an anti-bot agent has been recognized for years, also strikes one as being a suitable drug to try. Van Sacegham regards the destruction of the *Habronema* in the stomach as the ideal preventive measure against summer sores, arsenic up to 2 grains per diem being recommended.

His method of curative treatment for summer sores is as follows :—

Disinfect the sore thoroughly and then apply the following :—

Plaster of Paris	100
Alum	20
Naphthalene	10
Quinine	10

This rapidly dries the sore, prevents the attack of flies and prevents the animal biting itself. He regards it as a specific.

In conclusion, the writer would draw attention to the necessity for careful post-mortems on all debility cases, as it is comparatively easy to overlook the presence of these minute worms, more epecially *H. Muscæ* and *H. Microstoma*.

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SOME RICE-BREEDING EXPERIENCES

BY

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INTRODUCTION.

THIS paper is an attempt at placing on record some of the many experiences peculiar to rice-breeding on Mendelian lines. These relate to swamp rice and have been gained in the course of seven years of breeding work on rice mainly at the Paddy-breeding Station, Coimbatore, and secondarily in the Tanjore delta farm at Manganallur. No attempt is made to traverse the familiar field of paddy agriculture, nor to supplement in any way the scientific aspects of the work, the first instalment of which has appeared as a Pusa Memoir.[1] This article has been written in the hope that it may be of some little practical help to beginners in the same field, and also to stimulate an inflow of similar experience from other quarters, to the eventual benefit of all.

THE WORK.

Work on this crop is very difficult and trying, but the wealth of scientific material and the enormous economic possibilities easily provide the inspiration. Paddy work is work in puddle. Going about it with boots on is out of the question, the work being so intensive that the huge lumps of mud, getting lifted with each move, play havoc in the family of plants. Bare legs are thus a necessity, and clean *bunds* and scrupulous field sanitation are hence quite essential. To work under these conditions both fore- and after- noon is a physical impossibility and, therefore, puddle work is

[1] Parnell, Rangaswami Ayyangar and Ramiah. "The Inheritance of Characters in Rice, I." *Memoirs of the Department of Agriculture in India, Botanical Series*, Vol. IX, No. 2.

confined to forenoons only. The afternoons, when spent in the fields, are best done comfortably with dry feet, quietly walking along the *bunds* and drinking in the general impressions of the various plant groups. I would strongly advocate the most thorough and intimate touch with the plants handled, be it counting the number of tillers, marking the flowering dates, measuring the heights, or noting the more detailed characters incidental to the intensive study of one and the same crop. There are not always big, broad and patent differences. Everything, however minute and insignificant, counts. It was a pleasant surprise to have noticed that what passed for two identical varieties of paddy proved to have had their only difference in the colouring of the tiny little downy growths from which the pedicle of the spikelet originates. So also with the operations. Nothing is trivial, nothing to be lightly brushed aside—vigilant care at every step. I am strongly in favour of every breeder going personally through each unit of experience so that, in the fulness of intimate knowledge, he can safely guide the various human units contributing to the common work. Another point of great importance is to manage to spend as much of one's time as possible among the plants. The more one moves among them, the more does one get to know them. There is always some revelation in store.

THE PLOTS.

An intimate touch with the whole of the farm area is an essential requisite of all breeding work. The oddities of every nook and corner should be known. With this intimacy, the correct block of plots should be chosen, suited to each group in the cropping. There should be plenty of *bunds*—all being parallel either way. The main *bunds*, marking each distinct drop in the general contour of the area, should be at least three feet wide, the subsidiary ones being eighteen inches. The channels are to vary from one to two feet in width according to their location. Of these, too, it is desirable to have as many as possible, in view of each channel combining both the irrigation and drainage of the fields below and above it. The irrigation water should be let in at one corner of the field, run across it, and let out at the corresponding diagonal corner. This

minimizes the effects of the fresh current of silt-laden water, in its possibilities of inducing uneven growth. Close after the letting in of water puddling commences, and water is allowed to stand in the fields. Now is employed what the station calls a "scum boy," whose business it is to be continually removing the floating scum and debris from the corners of the fields to which these get blown during high winds. This removal, if vigilantly done, reduces considerably the extra fertility and delayed ripening which are a common feature of the crop in all such corners. Another local disturber is the dung of the ploughing and levelling cattle, the prompt removal of which is essential to uniformity.

Seedbeds and sowing.

Paddy seeds have to be soaked in water, drained, sprouted and then sown. Soaking, in the case of single plants, is best done in the wide-mouthed, tin screw-top bottles in which the seeds are stored. The naphthalene balls put in against insects should be removed. The paraffined label emerges through the soaking safe and sound. The tin screw-top gives security, and the wide mouth is an obvious convenience for the easy pouring out of the seed. The draining is done by placing a wire mesh over the mouth and gently inverting the bottle. This takes out almost all the water, and what little is left is drained thoroughly by repeating the process over a piece of fourfold blotting paper and letting the bottle remain inverted for about ten minutes. The next step is to pack the seed mass at the bottom of the bottle, pushing down the seeds sticking to the sides. This over, the bottles are arranged in a box which is left covered with a wet gunny bag. The next day the seeds sprout and are ready for sowing. They are emptied into the palm of the hand and sown. What remains at the bottom or sticking to the sides of the bottle is brought together by taking in a little water from the channel, giving it a sharp twirl and briskly pouring the contents out into the palm, when it will invariably be found that the bottles remain absolutely emptied. Paddy up to half a pound is easily soaked in wide-mouthed bottles, and for larger quantities muslin bags have to be used in the ordinary way, one for each unit

of about 3 to 4 lb. Drill bags have proved unsatisfactory, being close-meshed and hence difficult to drain properly.

Seedbeds for single plants are made in strips three feet wide and as long as the size and quantity of seeds sown. The big range of variation which makes it possible for over 10,000 seeds of *Jeeraga Samba* to be in a four-ounce bottle which would take in only about 3,500 seeds of the big *Kallundai*, shows the need for adjustments suited to the variety. But it will be found with a little experience that the budgetting of sowing room is a comparatively easy matter. Three feet is a convenient width for a range ensuring even-sowing from one side of the plot—the row of plots contiguous to it between two channels, standing in the way of getting at each individual plot from both sides. In the case of bulk sowings, strips, six feet wide and running the whole width of each big plot, afford a convenient breadth for sowing by going round the plot once—each side serving a range of three feet. Long, narrow plots ensure good levelling, even-sowing, good germination and an even-stand. The channel between two rows of plots is about 2½ feet wide, part of which is occupied by the thin *bunds* forming it and marking out the plots which are thus left with a clear width of three feet. This channel provided soil for the plot *bunds*, and, now that the plots are ready, serves as an irrigation channel, drainage main, and highway to the row of plots—all in one.

Labels.

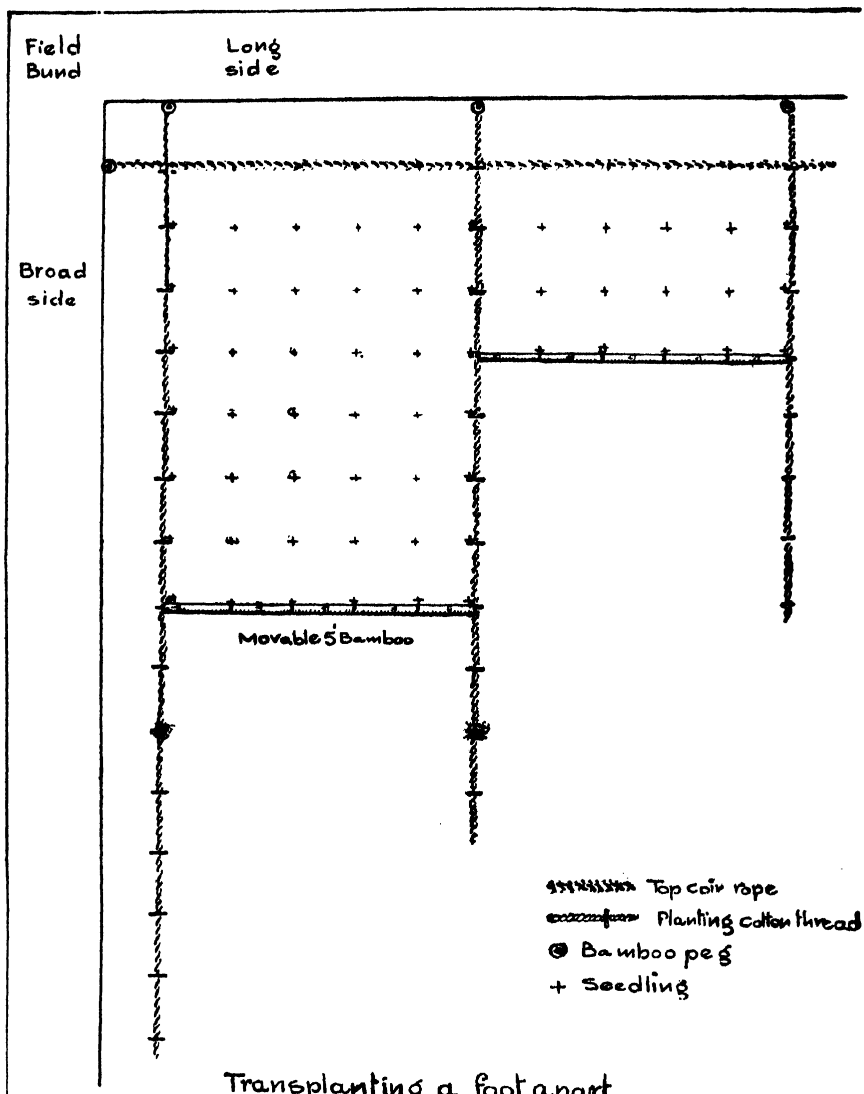
Chips of light wood about 3½ inches long and an inch wide, with a hole at the top to take in a thin iron or copper wire which fastens them on to a bamboo stake 3½ feet long—this is the commonest field label. The numbers are written with black japan. At the end of the season the numbers are shaved out and a fresh surface exposed. The labels are made of sufficient thickness to stand the shaving a number of years. Stakes should be of mature solid bamboo sides, and are kept serviceable fairly long if heavily tarred at the end of every alternate season. Eyeletted card labels with hempen twine to serve for fastening are most commonly used. A thin herbarium millboard is easily cut into any number and kind of

labels, and with a pair of punch pliers and a good stock of hempen twine the label problem is easily solved. All card labels should be paraffined after being written on. I have found that holding the ends of the hempen twine and dropping in the written label into paraffin very near boiling, and letting it simmer along for a few seconds, works the paraffin thoroughly through and leaves it with a decent glaze and no daub.

TRANSPLANTING.

Transplanting in bulk is done ordinarily about 9 inches apart. Blocks intended for *seed* multiplication are preferably planted in rows a foot apart, and the plants about six inches in the row. In every case it is best to leave a foot all round the field unplanted. This is easily done by putting a coir rope tight between two pegs planted a foot away from the *bund.* This rope line is planted out first and the centre filled up as the rope planting party is going ahead. There is often a tendency to plant these rope lines a bit too close, and this should be avoided. The advantages of leaving a foot all round are: (1) the *bunds* are easily kept clean with considerable diminution in chances of disease, (2) the general field sanitation is better attended to, (3) there is enough safe room to move about among the fields without brushing against crops flowering or heads mature, (4) the border plants do not get extra vigorous and extra tall and mar the evenness of the block, and (5) the planted blocks get to be at least about 3½ feet from each other (allowing for the eighteen-inch *bund*)—a condition which considerably diminishes the chances of natural crossing. Character lots and lots intended for intensive economic study are planted one foot apart either way. For this purpose two coir ropes are put in position one foot away from the top and bottom *bund,* respectively (*see* Figure). These two *bund* ropes, being parallel, serve as it were as rails along which to move the actual planting ropes. These ropes are of strong twisted cotton thread, about the thickness of a diary pencil, soaked well in water and stretched out tight to ensure against any undue lengthening out during the continual soaking they are soon to experience. These ropes are secured to pegs at each end. Starting

from the top peg at intervals of every foot is inserted a bamboo slip about an inch and a half long, grooved breadthwise about the



Transplanting a foot apart

middle to take in the thread and get securely sewed on to it. Two ropes are laid across the width of the field, the first one a foot away from the *bund* on the breadthwise side of the field. The other rope is laid parallel five feet away from the first one. There is thus marked out an oblong five feet wide with foot-marks on either side

of the ladder as it were. The many bamboo bits along this rope serve to keep the rope line clear and prevent an easy imbedding into the soft puddle on to which it is laid. This five-foot width represents the convenient planting range of one woman. More ropes could employ more women. For rapid planting two trained planters could be put into one gap. In actual practice the breeding station uses in each of its two or three planting parties six ropes in the five gaps of which work ten women. At this rate a decent area is covered per day. Each woman has a bundle of seedlings in her left hand and a five-foot bamboo with bold foot-marks in the other. This bamboo is laid across the planting gap between the ropes from bamboo bit to bit and a seedling planted at each mark of the bamboo. One line over, the bamboo is removed to the next foot-mark moving backwards and on and on till the gap is finished out. One of the planting ropes is then moved down to bring about the next five-foot oblong, and when this too is planted up the operation is repeated till the whole field is covered. For the sake of convenience, every tenth bamboo slip has a bit of coir rope prominently knotted round it so that at the bottom row the correctness of the counts is easily checked from the nearest knotted tenth. There is a reserve of marked rope twisted round the bottom peg, to admit of usefulness in fields of varying width. Care should be taken that as the women walk back no seedling is planted into the hollows of their footmarks; but the women easily learn to level out the bamboo zone prior to planting the seedlings. This system of space-planting has, with all the little modifications and accessary aids acquired in the practical working of any system, been so perfected that the whole operation works very easily and quickly. All that is required is two men, one on each side of the *bund*, to move the ropes along, plenty of five-foot bamboo sticks and a few 4, 3, 2 and 1 foot sticks for interim and final adjustments, which the length of the field and the quantity of the available seedlings might necessitate. A casualty in a foot spacing means a gap two feet square, and this will, when any economic problem is involved, eliminate the usefulness of the eight adjacent plants. It is hence desirable that as far as possible there should be no gaps. To ensure this, only good and healthy seedlings

are planted. A system of filling in gaps, a few days after transplanting is over, has been practised, and for this it is advisable to maintain a reserve of spare seedlings by planting an extra middle row six inches apart in the end two or three rows of each block. These might later be moved into the gaps if any, or pulled out. The fields have to be absolutely level and there should only be just enough water to let the bamboo lie slightly imbedded in the soft mud and prevent it floating. For safety against wind the planting is begun from that side onto which the wind blows, and to guard against bending and breakage of the seedlings planted their tops are nipped off. If two blocks are planted side by side a two-foot interval separates them. Crabs have occasionally given trouble by nibbling the seedling at the base and have proved, especially at Tanjore, a nuisance to the sprouting seedlings, and the only curative measure against them was to put a few women to be continually catching and destroying them. The tiny little ones slip through this campaign and a cheap and effective method of getting rid of these is yet to be suggested.

FLOWERING.

Even heading being an important economic factor, a system of noting the degree of such evenness has been devised. Progeny from a single plant are all planted one foot apart either way, so as to form a block. Bamboos are stuck in at every tenth plant both lengthwise and breadthwise. This marks the block out into regular sub-blocks ten square—so much so that from any place in the block the location of a particular plant is easily made, *e.g.*, 27th row 16th plant, reading down with the help of the bamboos. Having fixed the latitudes and longitudes, a chart is made out, in which each square represents a single plant and the date on which that plant flowers is entered. A cooly trained in this work walks up and down the line and shouts out the particular plant in flower and a literate subordinate sitting on the *bund* opposite follows him in the chart and notes the date. For purposes of flowering it has been found convenient to note the date on which the first main head emerges out of the sheath and shows out the white downy ring at the bottom of the panicle. Casualties in the

block are marked zero. If the flowering runs through parts of two months, beginning late in one and running long through another, an additional letter is added to the fewer group of dates, *e.g.*, 29th December to 10th January: the squares entered up in December will have 29 D, 30 D, 31 D, and the other entries will be simply 1, 2, 3, etc. The entries being over, the results are tabulated and put on to a graph. It has been found in practical experience that marking flowering is better done on alternate days, as this means less trampling about, more lots to handle and a larger evenness in the distribution of the numbers obtained on tabulation. This method of marking flowering has been of very great help in estimating the range of flowering in a pure family as also in very many families splitting for this factor. Various interesting correlations with other morphological factors have thus been enabled to be worked out.

SELFING.

Selfing is a necessity and as it does to a small extent interfere with the very free setting of the seed, it is desirable to confine this to absolutely necessary cases. There have been stray instances in which the colour of the paddy was interfered with on bagging, and it is therefore desirable that one or two plants in a selfed group should be grown naturally to serve as a check. The bagging is done as follows :—A bamboo is planted close to the plant to be bagged, it being at least nine inches taller than the probable height of the plant when heading is over, and three more bamboos take their place on three corners of the plant just as wide away from it as to allow of enough spread inside. Care should be taken that one of the bamboos takes its place on the side from which the prevailing winds blow. This ensures a wedge-shaped frontage to the bagged area and leaves the bag secure even in heavy winds. A triangular bag about a foot each side is then slipped over this frame work, down to well within about a foot of the highest water level and secured to the bamboo at the corner of its bottom edge on the windward side by means of a tape sewed on to the bag. The plant is labelled both to the central bamboo and to one of the outside ones. The central bamboo being taller prevents a cup-shaped

depression and secures a pyramidal top. The cloth used is the muslin commonly known as 1702 mull—manufactured by J. & A. Leigh, Preston. With proper care a bag easily lasts for three years. Two precautions have to be taken. The bamboo must be smoothened at the nodes and the top of it is to be a nodal septum, smooth and rounded out, so as not to take in and retain any rain water. These precautions prevent the bag from rapid depreciation and tearing, and make it last long. The bagged plant has its old lower leaves scissored off, and a string is *loosely* passed round the plant to keep the outer row of tillers from rubbing against the bag during growth. The string when put round too tight has interfered with the free ventilation of the tiller mass and has resulted in damage to a few central tillers. The bag may be removed when all the main heads have finished flowering, and what few heads may come out later can be cut away, leaving the initial bunch of prime heads free to be gathered when ripe, without having to wait for the weakling stragglers.

ROGUES AND ROGUING.

I consider roguing the most fascinating of all experiences. The amount of natural crossing in rice has been variously estimated up to about 3 per cent., and this offers one of the natural sources of the presence of rogues in a pure crop. Added to this are the immense chances of an odd grain or two getting mixed with a pure lot in a hundred little ways which will be within the experience of anyone handling lots running often over a thousand. These unwelcome plants are of two kinds: (1) mixtures and (2) natural crosses—the mechanical mixtures and chemical compounds of genetics. Both are undesirable and should be watched and promptly pulled out to maintain the purity of the family. A stranger plant is easily detected, in that it flowers either very early or peeps out green when all the neighbours are ripe. Its colour and habit often mark it out. Anyway it is easily detected and dealt with. In the case of contemporaries they cease to be strictly such, and are often ahead of the family. Extra vigour, a marked prominence right from the start, often a difference in habit, mark these out easily. It is a common experience that after a little time one gets easily to develop

an eye for a rogue. In the seedling stage itself, a keen eye easily detects what is sure to prove to be an intruder, and often the suspicion turns out at flowering time to be well founded. In a non-purple-pigmented variety, pigmented strangers are easily spotted. But colourless rogues are a hard lot and give more trouble. Habit, height, duration, and above all the general droop of the panicle provide guides to them. In an even-flowering variety with a continuity of stretch in the heads, a stranger strikes a discordant note and arrests the attention of the passer-by. It is highly desirable that anything suspicious, well or ill founded, is pulled out straight away before its dubious pollen begins to taint the neighbours. This may mean innocent victims, but it is better to err this way. I have come across instances of a few early heading plants true to type, and a fair number of these isolated and grown proved to be slightly pigmented rices. This apart, it is desirable to eliminate the stragglers, both early and late, as by so doing we eliminate the chances of accentuation of uneven heading in the next season's crop. A most efficient method of trying to locate a rogue is to sit on the *bund* and look low and level with the height of the plants, and any plant sticking up easily betrays itself. This means a margin to the plant block, not extra high and giving the block the look of a very shallow dish, but the securing of a normal margin. The leaving of a foot all round the plot is useful in this as in other ways. Roguing involves continual movement among the plants, and as it is not desirable to disturb plants in shot-blade by indiscriminate treading, the desirability of definite spacing, with consequent interspaces, becomes patent. They ensure safe movement and have the additional advantage in that the regularity of planting serves to tune up an orderliness and uniformity, in which anything out of the way is spotted out easier. Roguing has to be done at three different periods: firstly, before the variety is in general flower, secondly, during full flower, and, thirdly, when flowering is finished and late plants linger on. The most desirable thing to do is to move about the plots continually and pull out plants any the least suspicious, immediately they are detected. It is not desirable to postpone doing this, as once lost sight of they are not

very readily spotted out again. Light has an important influence on the ease with which a rogue is spotted, and it will fall within the easy experience of one in the work to be surprised to find that a rogue quite near one *bund* was missed till its presence was revealed from the distant *bund* opposite. In my opinion it pays richly to examine a crop from all positions and at varying times.

All this refers only to pure families and bulks, and I would here give a warning against any interference with definite splitting families, as what a beginner would lightly take for a " rogue " often proves the very plant with that rare chance combination of characters we are all delightedly familiar with in the course of Mendelian experiences.

STORING.

In breeding work we deal with large numbers of *single plants* and when any of these get multiplied we get what is a *pure bulk*. It is the handling and safe storing of these that will now be considered. The single plant is best harvested close below the panicles, and the whole lot of heads is then put into a long muslin bag. A label is put in and a knot secures the mouth of the bag. Another label is tied round the neck below the knot. This guards against mixture and impurity. The only chances of any stray seed coming in will be through sheer neglect, and to guard against this the mouth of the bag is examined before unknotting it, and later when the heads are removed for stripping the seed off the panicles, the bag is turned inside out and all stray grains carefully removed prior to storing away the bags. These single plants in muslin bags are safely and easily put out to dry and are then stored packed in bins, till the stress of the harvest is over and time is found for stripping and bottling them. The stripping is easily done, a cardboard winnow proving quite efficient and not harbouring stray grains. This over, the seeds are put into wide-mouthed, tin-screw top bottles. These bottles are of varying sizes, *viz.*, 4, 8, 12, 16 and 20 oz. capacity. For ordinary purposes, 4 and 8 oz. are the sizes for single plants, and very occasionally a 12 oz. bottle may be needed to take the seed of an extra vigorous individual. These bottles are very convenient and highly commended for general use in all paddy work. A numbered card label dipped in liquid paraffin is put into

the bottle, as also a *ball* of naphthalene which ensures absence of moths without in any way seriously impairing the germination capacity at least for a couple of seasons. The naphthalene ball is of course removed prior to the soaking of the grain for sowing. Larger quantities of paddy up to about 10 lb. are easily stored in drill bags about a foot square. These have to be carefully stitched so as to allow of easy examination of chance seeds in their stitch folds, and to have a tape loop sewed on to one end of the mouth for convenient labelling. The neck is secured with a tape, and inside the bag is put in the wooden labelled chip marking the plot in the field. Still larger quantities, up to about 25 lb., can be stored conveniently in kerosene tins with well-made lids fitting on to the top cut entirely out. A little tin loop soldered on to the *body* of the tin (not the lid) is the provision for tying the label. The soldering of the bottoms of the tins as purchased is often imperfect, allowing of chinks harbouring stray seed, and these have to be beaten close and if need be resoldered and filled up. For very large quantity of seeds bins somewhat similar to those described by the Howards[1] are used. The last thing to use in a paddy-breeding station—though without it, it is well nigh impossible to get on—is a gunny bag. It is a treacherous receptacle, bristling with possibilities for acute trouble regarding the purity of the seed handled and stored. The best way of minimizing this necessary evil is to purchase *new* gunny bags and keep up a steady inflow of this, as seeds go out of the station in the previous year's bags. The fresh ones should be used for the new year's *seed* and the old ones for other less important storing. It pays well to keep a man going over emptied bags, bins, tins and bottles, and make sure that no odd grains lurk inside them. It would fall to the easy lot of all breeders to come across servants possessed of great care and absolute veracity, to whom this work is very safely entrusted.

Before concluding, I wish to express my grateful thanks to Mr. F. R. Parnell, Government Economic Botanist, whose genial encouragement gave me ample opportunities for the gathering of these experiences.

[1] *The Agri. Journ. of India*, XV, Pt. 1, p. 9.

Selected Articles

THE GROWTH OF THE SUGARCANE.*

BY

C. A. BARBER, C.I.E., Sc.D., F.L.S.

VII.

THE length of the cane depends on two different factors, the length of the individual joints and their number. Taking the cultivated cane plant in general, there would not appear to be much difference among the varieties in these respects. In every case the number of joints is considerable, for as each joint bears only one leaf and these are constantly growing old and being discarded while new ones are appearing at the top, the continued formation of fresh joints is a necessity in a growing plant. Given the conditions necessary for continued healthy growth, the plant will thus go on forming joints until it dies or, as is so often the case, arrows: then all growth in length ceases. Joints once formed and meeting the eye of the observer do not increase in length, for, as we saw in the last article,[1] the increase in length of the individual joint takes place while it is still hidden in the mass of young leaves and, indeed, completes itself in a very short time. After that, the joint never alters in size, and the increase in length of the cane is entirely due to fresh joints being added above those already formed. By counting the joints at harvest time, we can at once tell how many leaves the plant has produced above ground, those in the terminal tuft being of course added.

* Reprinted from *The International Sugar Journal*, July 1920.

[1] *The Agri. Journ. of India*, Vol. XVI, Pt. 1.

In spite of this general uniformity, we have short and tall canes, long and short-jointed forms, canes with comparatively many or few joints. And these are, all of them, matters of importance in regard to the amount of crop yielded. The height of a field of cane will, as everyone knows, vary a good deal according to the weather, the soil, and the care in cultivation and amount of manure applied. And the effect of these external variations is perhaps more to be seen in the length of the individual joints than in the number produced. The length of the joints is immediately affected by any local injury, the plant reacting against such injury by producing for a time, or permanently, shorter joints: and any cane not growing well will show its condition in the joints as well as in the leaves, by producing shorter ones. Thus B.208, which has been most extensively tried in all parts of India because of the richness and purity of its juice, has on the whole been disappointing, being usually characterized by thick short joints with a strong tendency to shooting at the nodes. The climate appears to be generally too dry and perhaps the heat is too great for this cane to do well; but the writer has met with it in two widely separated districts where good, long joints are formed without much shooting, and the canes here were of so different a form that it was difficult to believe that it was the same kind of cane. Repeated observations have shown that in no character does the cane plant respond more rapidly to climatic conditions than in the length of the joints: and in parts of Bengal, at reaping time, the portion of the cane growing at the onset of the monsoon can be readily marked. An extreme case of this kind of periodic change in the length of the joints is shown in the reproduction of a photograph shown on Plate XIII. Beyond that these canes were grown in Central Queensland nothing is known of the details of the crop, but it would have been interesting to learn what was the cause of the change. It may be suggested that the simultaneous shortening of the joints in all the canes of the crop shown had something to do with the approaching end of the growing period: but its long continued nature might also suggest a marked period of drought succeeding good growing weather. We shall return to this aspect of the subject later on, merely

A Queensland Crop of Canes showing a sudden Change in the Length of the Joints.

noting here that sudden climatic changes have again and again been seen to produce similar changes in the length of the joints.

Another factor which has influence on the length of the cane joint in a given plant is the period at which it is formed. We have seen[1] that the early and late formed canes of a clump differ very considerably in this respect. The first formed canes are distinguished, among other things, by relatively shorter joints than those arising later in the plant's growth ; but, in spite of this, the earlier canes produce so many joints that they are usually the longer. This makes it rather difficult to determine accurately the appropriate length of joint in the different varieties. But a further difficulty is met in the fact that in each individual cane the length of joint varies a great deal with the part of the cane where it is measured. Commencing with extremely short, disc-like joints in the part usually below the ground, where the plant is engaged in attaining the thickness proper to the variety,[2] the length of the first joints above ground rapidly increases as we pass upwards. During the period of active growth a succession of good, long joints is formed and, towards the close of this period, they often become quite short before the cane is cut at harvest. When flowering occurs this normal curve of growth is interrupted at the end, in that the joints at the top become longer again, sometimes enormously so, and it is thus possible to tell, long before there is any appearance of the future inflorescence swelling within its sheath, that the cane is going to arrow : the leaf sheaths become also longer while the blades become shorter, and the joints greatly decrease in thickness and become useless for the crop.

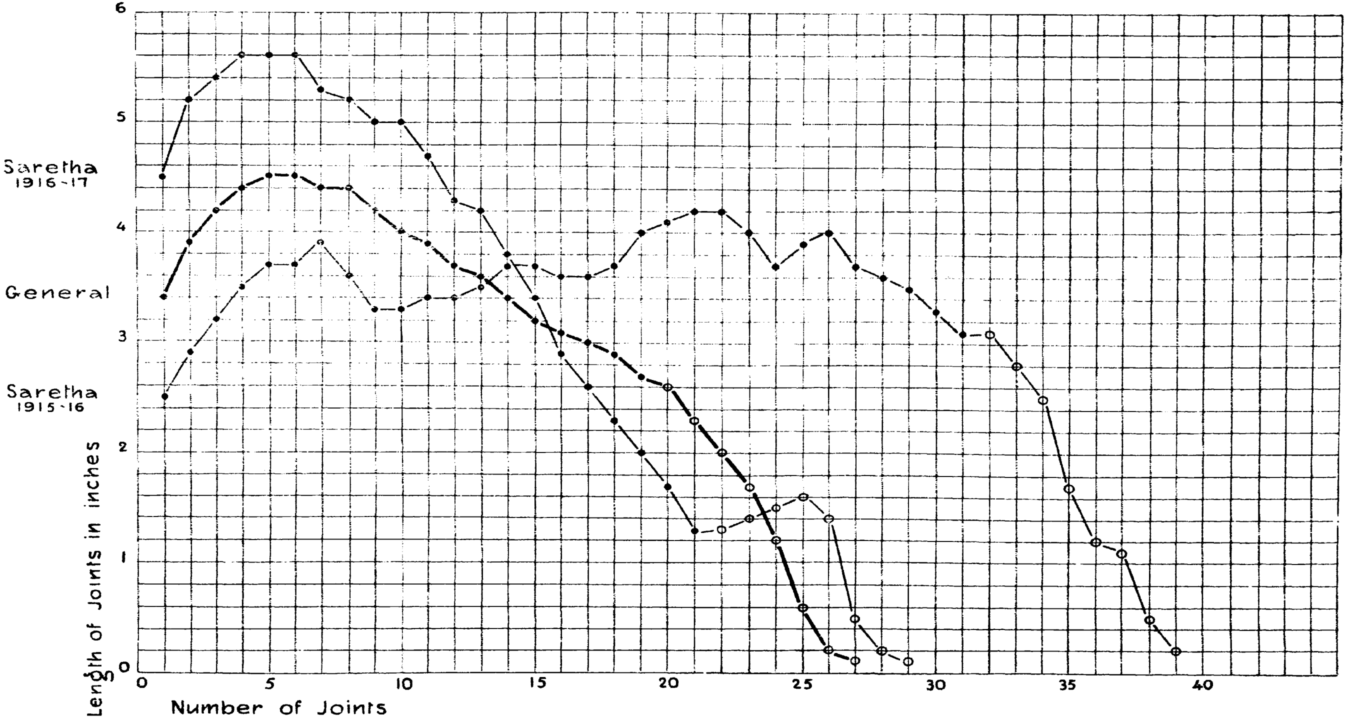
In attempting to judge the length of joint appropriate to the variety, one would in these circumstances naturally confine one's attention to the middle of the cane, assuming that in this part the joints would remain more or less constant and indicate the normal length attained. But this is far from so simple a matter as it appears, for the joints vary a great deal even in this part, and there is some

[1] *The Agri. Journ. of India,* Vol. XV, Pt. 6.
[2] *The Agri. Journ. of India,* Vol. XVI, Pt. 1.

evidence of a rhythmic change in length during active growth, waxing and waning periodically. But the most important point brought out by a careful study of a very large number of canes is that the longest joints are to be found much nearer the ground than the middle of the cane. The length of the joints from base to apex has been measured by the writer in many thousands of canes, and in a batch of 2,000 belonging to widely different varieties (entailing some 40,000 measurements) it was found that, on the average, the fifth and sixth joints above the ground were the longest. It was also noted that the very first joint above ground was comparatively long, that the increase in length was very rapid till the maximum was reached, and that, further up the stem, there was a regular fall until the short joints at the end of the growing period were reached. As there were, on an average, 20 mature joints in each cane, the point at which the longest joint was met with was thus exactly one-quarter of the way up, counting the number of the joints. The following were the averages, in inches, for this series of measurements, from the ground to the highest matured joint of the cane :—3·4, 3·9, 4·2, 4·4, 4·5, 4·5, 4·4, 4·4, 4·2, 4·0, 3·9, 3·7, 3·6, 3·4, 3·2, 3·1, 3·0, 2·9, 2·7, 2·6. These figures of the average length of joint in the 2,000 canes are graphically shown in the accompanying diagram in the curve marked 'General,' and this graph shows very clearly the typical joint curve of a sugarcane (Plate XIV).

At the same time that the joints were measured in all these canes, various other measurements were made, including the lengths of the leaf blade and leaf sheath, and typical curves were obtained which differed very widely from that of the joint. We can here only very briefly refer to that of the leaf blade. The lamina borne by the first joint above ground is usually about a yard long, and succeeding leaves are longer and longer until a maximum is reached, as in the joint. But this maximum, which is usually from 5 to 6 ft., is reached much later than in the joint. When it is attained the succeeding leaves remain very uniform in length during the period of active growth, while towards the end of the growing season the length rapidly decreases. The general curve is, therefore, a flat one as compared with the sharp-pointed one of the joint, and it is

Joint Length Curves, Saretha, Samalkota, in 1915-16 & 1916-17, & General Curve, of the Whole 89 Observation Units



The dots represent successive joints from left to right, commencing with the joint at ground level. The circles at the end represent the immature joints at the top.

probable that, as long as the cane plant is growing normally, the length of leaf blade remains fairly constant. As an example, we will take the measurements of the leaf blades in the Saretha group of Indian canes, and the averages given below are those of a very large number of canes in different numbers of this long-leafed group of canes. The following are the figures, in inches:—37, 38, 42, 45, 48, 51, 52, 53, 54, 55, 56, 56, 57, 57, 57, 57, 56, 57, 57, 57, 57, 56, 55, 55, 54, 54, 53, 51, 48, 37, 26, 17, 8. In this series it is seen that the actual maximum was not reached until the sixteenth joint, and that for 28 successive joints the differences in length were less than 10 per cent. All the leaves of the plants were measured from the first joint above ground upwards until a lamina was reached at the top of the plant less than 1 ft. long.

Let us now return to the curve of joint length, which concerns us more especially. From the mass of material recorded I propose to describe a case which shows that, with a little study, the length curve of the joints taken at harvest bears, indelibly stamped upon it, the nature of the past growing season, and that any abnormality will make itself clearly noticeable. This method has been extensively used in a paper by the author[1] dealing with the suitability of any cane for the locality in which it is growing, the observations being made once for all at crop time, instead of in a continuous series throughout the season. The work can thus be extended to a large number of districts by simply deputing a careful subordinate to make measurements according to a given schedule.

In a series of measurements thus obtained at Samalkota, in 1915-16, the curves showed certain peculiarities which tended to discredit the reliability of the method; those of the joint length in four kinds of cane, although agreeing remarkably among themselves, were quite abnormal; they even resembled the flat leaf curves rather than the typical sharp joint curves which had been

[1] C. A. Barber. "Studies in Indian Sugarcanes, No. 5. On testing the suitability of sugarcane varieties for different localities, by a system of measurements. Periodicity in the growth of the sugarcane." *Mem. Dep. Agri. India, Bot. Ser.*, X, 3, 1919.

obtained in hundreds of cases all over India. The curve obtained for Saretha in that year is shown in Plate XIV. It is seen that the maximum joint length, although approached in the seventh joint, was not actually reached until the twenty-first; that between the seventh and twenty-sixth joints only minor differences in length occurred; and that the curve was very long, no less than 33 joints being formed and matured before the rapid diminution of length at the top of the cane. In 1916-17 the observations were repeated at the same place with the same set of varieties which had been growing for the same number of months. In every case a typical joint curve was obtained, and that of Saretha is again reproduced on the plate. Saretha is a cane that has a rather greater number of joints than most others and, in the second year, it is seen that they were not appreciably more than the average for the whole series of canes of this and other varieties dealt with in the 'general' curve. The canes in this year were, therefore, just as few-jointed as those in the previous year had been many. The maximum is high, as is usual with Saretha, was reached very quickly, namely, in the 4th joint, but the descent was more rapid than usual to the 21st, when the immature part of the cane was reached.

As this divergence of the joint curves (shared in by those of the leaf, lamina and sheath) was so unusual, a careful study was made of the weather records published every year by the Station. The explanation was at once found there. To summarize, the monsoon was delayed in 1915-16 and the canes had a difficult time at the beginning of the season: later on things improved and the latter half was peculiarly favourable to rapid cane growth. In 1916-17, on the other hand, the monsoon broke very early and the rain was satisfactory right up till October, when canes were commencing to be formed rapidly: then the difficulty, often experienced in the delta, was to get the land drained, and even paddy suffered considerably from the excess of water on the land. In both seasons the amount of rain that fell was reported to be 'well above the average': in 1915-16 the first half of the season was unusually bad and the second unusually good: in 1916-17 the reverse was the case.

This clearing-up of the difficulty was opportune, and added strength to the conviction which was forming in my mind that a series of careful measurements made at crop time may be relied on to reproduce the character of the cane growth throughout the season that has passed. Further, that from a study of the joint and other curves of growth, obtained by local officers, the suitability of a tract for cane growing in general may be judged, and reliable data may be obtained as to the relative suitability of a number of different varieties being tested.[1]

[1] C. A. Barber. *Ibid.*

PROSPERITY AND DEBT IN THE PUNJAB.*

BY

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It has been said that nowhere in the world will you find a prosperous and contented peasantry. A perusal of the Land Revenue reports of the last 15 years suggests that the Punjab is perhaps the exception that proves the rule. But this was not always so. Twenty years ago things agrarian provoked deep anxiety and clashing views. The agriculturist was losing his hold upon the land. Indebtedness was increasing. The area redeemed was always less than the area mortgaged; and the money-lender was master of the situation. At last, in 1901 †, after much enquiry and searching of heart, when even the Revenue pundits had nothing more to say, the bull was taken by the horns and the Land Alienation Act was passed. This Act has rightly been termed the Magna Charta of the cultivator. To him it is the only Act that matters. He can no longer be ousted from his land, and he is no longer as wax in the hands of the usurer. With it too has come a new era of prosperity. The price of land, in spite of the Act's restrictions, has doubled. In some areas it has increased fourfold. Credit has expanded, prices have risen, and a widely extended system of irrigation has made famine well nigh impossible. Finally, this is a point that all official reports stress, since the Act came into force the area redeemed has almost invariably exceeded the area mortgaged. Prosperity, therefore, reigns, and the Revenue expert, no longer anxious, sees his work that it is good. Such is the impression

* Reprinted from *The Ind. Journ. Eco.*, III, 2.

† The Act came into force in 1902.

made by the official reports and reviews of the last 15 years. It is a picture almost without shadow, and it must be admitted that such pictures are apt to be unreal; but then it is a picture of prosperity, and in the imagination at least prosperity has no serious shadows.

Turning now to the statistical statements that accompany the official reports, we are suddenly confronted by the unexpected fact that throughout this period indebtedness has steadily increased.* In 15 years (1903 to 1917) the net increase in the mortgage debt of the province exceeds 10 crores of rupees. Of this nearly 9½ crores falls upon owners and share-holders. Dividing the 15 years into periods of five years each, the figures in lakhs are as follows :—

	Rs. lakhs
1903–07	161
1908–12	231
1913–17 †	541

I have excluded the amounts for which tenants are responsible, as this article will deal exclusively with owners and share-holders. It will be seen that there is a rapid rise in the figures of the last five years. If indeed only the last three years are taken, the increase is startling, being nearly four crores of rupees. This is actually more than the amount for three years immediately preceding the introduction of the Land Alienation Act when the increase was only 3·11 crores.‡ This is the more striking as two years of the earlier period were years of famine and only one was a good year, whereas of the last three years the worst (1916) is officially described as "unfavourable" while the last (1915) is called "a record year."

It is curious that so remarkable an economic phenomenon as this steadily increasing indebtedness§, vitally affecting the condition

* Some deduction must be made on account of mortgages which at the end of a fixed period are automatically extinguished, but informal enquiry suggests that in most districts this form of mortgage is uncommon.

† Figures for the year 1917-18 were not available when this article was written.

‡ North-West Frontier Province excluded.

§ Some deduction must be made from the figures given above on account of mortgages to non-agriculturists, which under the Land Alienation Act are automatically extinguished after 20 years without payment. Informal inquiry, however, suggests that the deduction to be made on this account is small.

of over $3\frac{1}{2}$ million proprietors, should have passed almost unnoticed. Indeed diligent search through the official reports of 20 years has discovered only one or two allusions to the fact that the money borrowed by mortgage exceeds the amount discharged by redemption. Yet for over 20 years this has invariably happened. In 1896 it was admitted that indebtedness was rapidly increasing, but after that there is no further reference till 1910. In that year the redemption of 415,000 acres for two crores and the mortgage of a much smaller area for $2\frac{1}{2}$ crores is cited as evidence of the increased value of land. The more important point that it is also evidence of increased indebtedness is ignored. In 1913 there is a final allusion. In that year net mortgage debt rose by over 72 lakhs. The fact is recorded, but without comment. On the other hand throughout this period there are innumerable references to the fact that the area redeemed exceeds the area mortgaged, and again and again, with almost ritualistic repetition, the subject is made matter for congratulation. Doubtless acreage is an important consideration, but after all the prime object of a mortgage is money. If more and more money is raised by mortgage, the fact that at the same time the area under mortgage is decreasing does not justify unmixed congratulation. The official review of 1915 remarks that "it is very satisfactory to find that not only the proportion, but the actual area of land under mortgage is now less than in any year of which we have a record." Yet in this year net mortgage indebtedness increased by well over a crore of rupees. In the following year the increase is 140 lakhs, the highest figure ever recorded for the province. Turning to the year's report for some explanation of this we find the bare statement that "it is the first time in the last five years that the area mortgaged has exceeded the area redeemed." In 1917 *, the last year under report, the increase is only two lakhs less. This time we are promised an investigation, not however because for 20 years debt has steadily increased, but because for the second year running the area mortgaged exceeds the area redeemed.

* This article was written in November 1918. The report for the year 1918 is, however, no exception to what has been said above. Net mortgage debt in 1918 appears to have increased by over 150 lakhs, making a total increase of 430 lakhs for the last three years (1916—18).

In this connection there is a further point to note. Recent enquiries into the indebtedness of members of co-operative societies in the Punjab, who may be regarded as typical of the proprietors of the province, suggest that one rupee of mortgage debt means at least another rupee of unsecured debt as well: that is to say, that to estimate total indebtedness the mortgage debt should be doubled. This would mean that during the last five years the total indebtedness of owners and share-holders has increased by eleven crores, or over £7,000,000. For ten years, the figures would be well over £10,000,000. * In 1896, Sir Frederick Nicholson estimated the total debt of the Madras Presidency, which in population is now twice as big as the Punjab, at £20,000,000. An increase of £10,000,000 in ten years is, therefore, considerable, and the more surprising that the period is one of undoubted prosperity. It would seem that after all prosperity had its shadow, and that perhaps in India prosperity and debt go hand in hand. Before we come to any conclusion upon the subject, however, we must try and ascertain why indebtedness has increased.

In the face of the almost total silence of the official reports, this must naturally be a matter of considerable difficulty. Statistical statements are indeed the only guide. There are plenty of these. Their name in fact is legion; but as a guide they have something of the erratic nature of the first possessor of that name. It is not only that all statistics may easily mislead; but these in particular have been collected for a purpose which is quite different from ours and under conditions which are constantly changing. Thus in the last twenty years, two new provinces have been carved out of the Punjab, the North-West Frontier in 1900, and Delhi in 1912. Allowances too have to be made for changes in district boundaries, and a final difficulty is the elusiveness of certain statements which occasionally disappear from one report to reappear in another. The field of Indian economics resembles a vast jungle through which as yet there is no pukka road, but only tortuous and not very obvious

* The exchange is taken at 1*s*. 4*d*. At 2*s*. the amounts would be £11,000,000 and £15,000,000, respectively.

paths. It was, therefore, a temptation at this point to draw back and leave it to those more expert in statistics and economics to align the road. This attitude, however, never led to either adventure or discovery. I have, therefore, adventured, hoping that others may be tempted to follow in my track, and that so doing they may find the path less tortuous or at least more obvious than before.

The first point to note is that in the last five years, with the unimportant exception of Simla, every district in the province shows an increase in net mortgage debt, and even in the preceding five years, when the increase was much less, only four * districts show a decrease, which too is no more than a total of 6½ lakhs. It is clear, therefore, that the increase in debt is widespread, though in the north-western districts it is less marked than elsewhere.

There are 28 districts in the province, and as it is impossible within the narrow compass of an article to examine the conditions prevailing in each, I propose to take the worst cases, in the hope that where the malady is most pronounced the symptoms may be most evident. There are no fewer than nine districts, representing about one-third of the Punjab, in which during the last five years the increase in mortgage debt exceeds 20 lakhs. The figures, which are in lakhs of rupees, are as follows; and to show the rate of increase, figures for the preceding five years are given as well :—

	1908–12 Rs.	1913–17 Rs.	Total Rs.
Ferozepore	34,75	76,34	111,09
Amritsar	29,08	49,22	78,30
Sialkot	16,56	37,65	54,21
Lahore	21,43	28,29	49,72
Gurdaspur	14,05	31,68	45,73
Lyallpur	1,13	43,38	44,51
Hoshiarpur	12,00	29,13	41,13
Ludhiana	17,09	22,87	39,96
Jullundur	1,87	26,06	27,93

As there will be frequent references to these districts, a word may be said about each. Three of them, Sialkot, Gurdaspur and Hoshiarpur, are submontane districts highly cultivated, thickly

* Gujranwala, Montgomery, Multan and Dera Ghazi Khan.

populated and blessed with a good rainfall. Jullundur, Amritsar and Lahore belong to the Central Punjab, and are the home of the Sikh Jat, an excellent cultivator if somewhat extravagant in habit. Like the submontane districts they are highly cultivated, but being more irrigated are even more densely populated. The connection between irrigation and population is worth noting. Ludhiana is south of the Sutlej, and broadly speaking resembles the central districts, enjoying, however, less irrigation but more rain. These districts are the home of the small proprietor, whose average cultivated holding varies from ten acres in Lahore to three and three-quarter acres in Jullundur. Excluding Lahore, the maximum average is only six acres. There remain the two districts of Ferozepore and Lyallpur. In these areas cultivated holdings are for the most part larger, the average being 15 acres in Ferozepore and nearly 20 in Lyallpur. In Ferozepore large holdings prevail because the rainfall is too scanty to permit of a large population. Lyallpur is too well known to need description. It is, of course, the most famous of the Punjab canal colonies. On the whole these nine districts are typical of economic conditions in the Punjab, which is a province of small proprietors, with here and there a district of larger holdings. In only one district out of the 28 (namely, Hissar) does the average cultivated holding exceed 20 acres, and in 19 it is less than 8 acres. For the whole province the average is seven and a half acres.

The district that shows the greatest increase in mortgage debt is Ferozepore. In ten years, it has risen by over a crore of rupees. In two other districts, Amritsar and Sialkot, the increase exceeds 50 lakhs. Assuming, as before, that total indebtedness is not less than double the mortgage debt, we find that as many as eight districts each show an increase of over £500,000. * In Ferozepore, the amount is nearly £1,500,000. † As there are in the district about

* 75 p.c. must be added at present exchange (2*s*. 4*d*.)

† Further enquiry suggests that Ferozepore is an exception to the general rule, that total debt is not less than double the mortgage debt. The latter appears in this district to be much heavier than unsecured debt. Even so the increase can hardly be less than 1½ crores, which at present exchange is equal to £1,500,000 (September 1919).

150,000 owners and share-holders, this means an average increase of £10, or Rs. 150 per head, which, as money counts in India, is considerable. A report * of 1908 touches upon the subject, and though it is not very recent it is worth quoting as, so far as can be discovered, it is the only explanation of the increase in debt that the reports for the last 20 years offer for any part of the Punjab. "Owing," says the Deputy Commissioner of Ferozepore, "to the habit of excessive drinking in some cases and to gambling in others, the people mortgage their lands first to one, then to another for increased consideration, and again to a third person for a further increase during the course of the same year; and this fact alone accounts for the high figures under the head mortgage and redemption of mortgage." And he goes on to point out that at the same time a combination of good harvests and high prices for grain had led to an abnormal rise in the value of land, the implication being that this sudden access of prosperity in facilitating mortgage had led to an increase in debt. Here then prosperity and debt would appear to be intimately connected, and what is more serious, to have led to demoralizing † habits. As such the case is a warning to those superficial economists who regard material prosperity as the remedy of all evil. It would be unwise, of course, to apply this instance from a single district to the whole province. At the same time the fact that in the district which shows the most abnormal increase of debt, the phenomenon has been connected with demoralizing habits, shows the importance of the subject and the need of enquiring into the phenomenon as a whole.

Ordinarily, where small proprietors are concerned, the main causes of indebtedness are: (1) bad seasons, (2) increase of population without a corresponding increase in production, (3) expansion of cultivation, (4) splitting up of holdings, (5) purchase of land on credit, (6) high prices, and (7) facile credit. There are other causes such as intensive agriculture, which demands more capital, and

* Land Alienation Act Report.

† The assessment reports of the district (1912—14) also speak of "extravagance and dissipation" as prominent causes of debt.

the power of the usurer ; but for our present purpose these can be ignored, as intensive agriculture in the modern sense hardly yet exists, while the usurer is hardly ever absent. Thanks to the establishment of nearly 6,000 co-operative credit societies, his power in the Punjab is decidedly less than it was ten years ago, so that we can hardly look to him for an explanation of the rise in debt. To ascertain this we must now examine each of the causes given above as briefly as such complicated questions allow.

BAD SEASONS.

The first cause is bad seasons, or to speak more accurately, though less simply, seasonal vicissitudes, as it is not only the bad seasons that run the cultivator into debt, but also their great fluctuations. In India, outside the great irrigated areas, the harvest is a gamble in rain, and this produces the gambler's habits. The Indian cultivator, therefore, is not noted for thrift. Moreover, when holdings are small, even a moderate harvest may compel a man to borrow, and if interest is high it may be difficult to pay off the debt in a good harvest. The moderate harvest occurs more frequently than is supposed. Even in districts with a good rainfall, like Gurdaspur and Sialkot, the rain is apt to come at the wrong time or in too great abundance, with the result that there may be a succession of harvests none of which will be good and none positively bad. This has certainly been the case in Gurdaspur, and has probably had much to do with the increase of 32 lakhs in the mortgage debt of the district during the last five years. The small owner there is not a man of business. In a good year he lives well. In a poor year he borrows ; and this, owing to the high value of his land, he can do with ease. Looking to the province as a whole, however, we find that the harvests of the last ten years have been above the average. There have been no years of famine as in the nineties, and only two bad years, while four were definitely good, and one, as we have seen, was a record year. The remaining three were normal or slightly below normal. Accordingly, though a few individual districts may have suffered, we can hardly attribute the increase in debt throughout the province to the seasons.

INCREASE OF POPULATION.

Of the many causes of poverty which operate in a country like India, increase of population is the most serious, because where agriculture is stagnant mouths increase faster than food; and when agriculture is the only important industry few leave the village where they were born. The common attitude, therefore, which sees in an increase of population a sign of well-being, is fundamentally wrong. It can only be an advantage if production, agricultural or industrial, outstrips it; and even then, so far as industrial production is concerned, it is a doubtful blessing, as it leads inevitably to overcrowded towns at home and a struggle for markets abroad, and the latter as often as not ends in war. It was not, therefore, necessarily matter for regret that the last census disclosed a substantial decline in the population of the Punjab. The fact was, of course, deplored. Attention was concentrated upon the ravages of malaria and plague, and the economic advantage of a smaller population for the land to sustain was not considered. In the nineties both population and indebtedness rose considerably. I have little doubt that the one affected the other; and in view of the great increase in debt during the last five years, I would hazard the guess that the population is no longer declining,* but almost certainly increasing. At the same time, the fact that throughout the period of the last census indebtedness was slowly but surely increasing, shows that there are other causes at work.

SPLITTING UP OF HOLDINGS.

In a country where the laws of inheritance prescribe equal division of property between sons, an inevitable result of an increase of population is the splitting up of holdings, and when these are small, this is likely to be a potent cause of debt. In 1896, an exhaustive enquiry into indebtedness in four different areas was undertaken by Mr. Thorburn, Commissioner of Rawalpindi. In his illuminating

* Since this was written the mortality figures of the influenza epidemic of the autumn of 1918 have been published, showing a death rate of 5 per cent. of the population. This would probably falsify the guess made above.

report, which deserves to be republished, he says that the four most prominent causes of debt are fluctuations in yields, losses in cattle, the obligation to pay land revenue whatever the harvest, and the splitting up of holdings from the growth of population. The first two causes are really aspects of seasonal vicissitudes which have already been considered; and if one may judge by the assessment reports of the last ten years, land revenue is no longer a serious cause of debt. There remains the splitting up of holdings. Official statistics show that there are now 136,000 more owners and share-holders and 53,000 more holdings than five years ago. The increase in the case of the former is about 4 per cent. Each of the nine districts which we are specially considering shows a similar tendency; and in five, Lahore, Gurdaspur, Hoshiarpur, Jullundur, and Lyallpur, the provincial average is exceeded. In spite of a great expansion of cultivation, the effects of which will be discussed presently, the increase in share-holders has naturally led to a reduction in holdings. This has occurred in each of the nine districts in question. In the six in which the average holding is less than seven acres, the reduction varies from half to a quarter of an acre. For the province as a whole the average has fallen from eight to seven and a half acres. In itself this is, perhaps, not a change of much importance; but viewed as a continuing process it is one that may deeply affect the future welfare of the Punjab. Meanwhile there can be little doubt that, in at least seven out of the nine districts (in Lyallpur and in part of Ferozepore, the average holding is still large enough to bear reduction), the splitting up of holdings has been a cause of the increase of debt. The fact that the number of owners and the amount of debt have both increased more rapidly in most of these districts than in others, is at least presumptive evidence of this. In Jullundur, indeed, where there are nearly 10,000 more owners and share-holders than five years ago, and where the cultivated area has shrunk by 13,000 acres, it has probably been the determining factor, and perhaps explains why the increase in debt should have leapt up from less than two lakhs in the first half of the last decade to 26 lakhs in the last five years.

Expansion of cultivation.

Jullundur is one of the very few districts in which the cultivated area has declined. For the whole Punjab the last five years show an increase of over a million acres or $3\frac{3}{4}$ per cent. Much the greater part of this is due to the extension of canal irrigation. For canal cultivation more capital is needed than for dry. It is reasonable, therefore, to suppose that borrowing has taken place on this account. The effect of this upon an increase of debt may, however, be exaggerated. Thus none of the five * districts in which the expansion of cultivation exceeds 10 per cent. shows a remarkable increase of debt. Two of these, Mianwali and Dera Ghazi Khan, both Indus districts, while together adding 200,000 acres to their cultivated area, have not added more than 20 lakhs to their debt, which works out to Rs. 10 per acre. Moreover, in none of the districts in which debt has risen most, has the expansion exceeded 4 per cent. In three of them, the addition to cultivation is insignificant; and in one, Jullundur, there has been, as we have seen, a decrease. It would, therefore, be unwise to attach much importance to this factor. So far, however, as debt is due to an expansion of cultivation, it need not be regretted as it is productive debt.

Purchase of land on credit.

There is nothing dearer to the peasant proprietor than land. It is the alpha and omega of his life, and his only means of sustaining it. In a striking passage, Mill says: "When the habits of a people are such that their increase is never checked, but by the impossibility of obtaining a bare support, and when this support can only be obtained from land, all stipulations and agreements respecting the amount of rent are nominal. The competition for land makes the tenants undertake to pay more than it is possible they should pay." *Mutatis mutandis* this applies as much to the price of land as to its rent, and is one explanation why in the Punjab its price has more than doubled during the last 20 years. In the East, the primary

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* Montgomery (39 p.c.), Multan (15 p.c.), Gujranwala (13 p.c.), Mianwali (12 p.c.), and D Ghazi Khan (10½ p.c.).

value of land is social rather than commercial. It is one of the three things for which money is always forthcoming. The other two, of course, are a marriage and a case in the courts. All three are a common source of debt. We must, however, distinguish between the man who borrows to buy land which will yield enough to pay back both principal and interest and the man who borrows to buy it at an inflated price. The former is thoroughly business-like, but the latter is very much the reverse. Now that the price of land is abnormally high, borrowing to buy must, in nine cases out of ten, be thoroughly unprofitable. The purchase of land may, therefore, be an important cause of debt. On the other hand, as land is generally sold by one cultivator to another, it may be argued that the loss of the one being the other's gain, the net result upon total indebtedness should not be much affected. This would be truer if loans were repaid as readily as they are taken. Thus when, as must often happen, land is sold to meet debt, part of the price paid is probably retained for current expenses. If at the same time the purchaser has borrowed to buy, debt will increase more on the one side than it is reduced on the other. If this is correct we should expect to find the rise in indebtedness during the last five years accompanied by a rise in sales. This indeed is exactly what has happened. In the five years ending with 1912, land was sold for $7\frac{1}{2}$ crores, and in the last five years for 12 crores. There is, therefore, a rise of $4\frac{1}{2}$ crores, or an increase of 60 per cent. Turning to the figures for our nine districts we find the same feature. Lyallpur is the most striking case. In the earlier period, land was sold for 48 lakhs and mortgage debt increased by only one lakh, whereas for the last five years the figures are respectively 95 lakhs for sales and 43 lakhs increase of debt. The two are undoubtedly connected, and in the Civil Justice report of 1912 we read that "the acquisition of proprietary rights has left some of the Lyallpur zemindars short of ready money and they have sold or mortgaged their newly gained proprietary rights and decamped with the proceeds leaving debts behind them." In Ferozepore too a larger amount of land has been sold during the last ten years than in almost any district in the province, and, as we have seen, there is no district in which

indebtedness has increased more rapidly. On the other hand, large amounts of land have been sold in Multan and Gujranwala, which are not amongst our nine districts. Even in them, however, mortgage indebtedness has risen substantially during the last five years, the increase in each case being over 10 lakhs. It may, therefore, be concluded that land purchase and debt are connected, but the connexion is probably less marked in districts where money is plentiful.

HIGH PRICES.

We come now to high prices. It is commonly assumed that they are good for the cultivator, as indeed they are if he has more to sell than to buy, but if it is the other way round, he benefits no more than any other class of consumer. In India a man with 20 or 30 acres will often have more to sell than to buy, and if his land is secured against bad harvests by irrigation high prices are an obvious advantage. The canal colonies have felt this to the full as is shown by the large amounts of gold which they continually absorb. But in districts where the average cultivated holding is six acres or less, it is only in years of good harvests that there is much surplus grain to sell, while in years of bad or unfavourable harvests, for part of the year at least, grain will probably be bought rather than sold. Let us compare for a moment two districts as dissimilar as Gurdaspur and Hissar, the one submontane with a good rainfall, the other officially described as "arid" with a rainfall of less than 15 inches. Going from the one to the other is like passing from a wilderness into a garden. At worst Gurdaspur will always have some appearance of cultivation. In Hissar, on the other hand, in a bad year it is possible to ride for 50 miles and hardly see a green thing. Yet the surprising thing is that in Hissar the people are undeniably better off than in Gurdaspur. They are better housed, better clothed and probably better fed. Even at the end of a year which has given only 3½ inches of rain most people in Hissar had grain enough left in their bins to live on. Yet in November 1918, in Gurdaspur owing to a bad autumn harvest following upon a spring harvest which, though poor, was by no means a total failure, more people than not were buying grain (rice and maize) at Rs. 5 a maund.

The last and most telling point in the comparison is that debt in Gurdaspur is much higher than in Hissar. Thus if we take the Sirsa Tahsil of the latter and compare it with the Shakargarh Tahsil of the former, both being areas that are almost entirely dependent upon their rainfall, we find from enquiries recently made that in the Sirsa Tahsil the indebtedness of proprietors is about ten times the land revenue, while in the submontane Tahsil of Shakargarh the multiple is as much as 25. Further, in the former 26 per cent. of the proprietors are free of all debt, and in the latter only 3 per cent. One explanation of the difference is over-population, which neutralizes all the advantages of Nature. Hissar, with a cultivated area of 2¾ million acres, has to support a population of only 850,000, whereas to feed a slightly smaller population (837,000) Gurdaspur has only 833,000 acres. In Hissar, the average cultivated holding is 22 acres against 6 in Gurdaspur. In the former, therefore, a good year will produce a large surplus of grain which can either be stored against a bad year or be sold to great advantage. In Gurdaspur, this is generally impossible. It is not surprising, therefore, that it is one of the most heavily indebted districts in the Punjab, and it is significant that the only district which is more heavily mortgaged is the adjoining district of Sialkot where conditions are similar. High prices combined with poor harvests have accentuated the evils of over-population. And in this connection it has to be remembered that while the cultivator sells in a cheap market, as a retail purchaser he buys in a dear one. Accordingly as a consumer he feels the full effect of a rise in price, but as a producer he cannot gain its full advantage unless sale is co-operatively organized. This may explain why the last three years, which have all been years of war and abnormal prices, have seen so startling an increase of debt.

Facile credit.

A recent American writer on rural economics says that "farmers who do not keep accurate accounts and who have not a keen sense of values should avoid the use of credit as they would the plague." This is a counsel of perfection. All the world over the small proprietor, provident or improvident, must borrow. It is important,

therefore, that his credit should be both cheap and good. So far as it is only cheap it is a danger. It is the primary object of co-operative credit to secure that when credit is cheap it shall also be good and when good that it shall also be cheap. Where, however, the cultivator is left to himself, his credit will more often be cheap than good. The high value of his land makes borrowing a matter of ease, and the more valuable it becomes the more he is tempted to borrow. It was this that made an official of the Central Provinces write in 1889, "the owners of the land grow poorer, while their land is daily rising in value." Pope expresses the same idea when he says :—

"The devil's grown wiser than before;
He tempts by making rich, not making poor."

In the Punjab, Mr. Thorburn, to whose report we have already alluded, traces the beginnings of serious indebtedness to the seventies, when it became an easy matter to alienate land. Since then its value has steadily increased, notably in the last ten years, during which the price of cultivated land has risen from Rs. 75 an acre to Rs. 186, a rise of 148 per cent. In the same period debt has also increased enormously, and the theory may be hazarded that in a country of uneducated small proprietors, unless credit is controlled, debt will always rise in close ratio to land value, that in fact debt follows credit. In Sir Frederick Nicholson's well-known report on co-operation we read that even in so thrifty and educated a country as Switzerland an abnormal rise in land values led to the peasant proprietors becoming much more indebted, which shows, as Sir Frederick says, that "even in countries of good education the peasant proprietor cannot refrain from pledging any additional value which the land may acquire." The remark applies with double emphasis to India and its illiterate masses. To them a sudden rise in the value of land may be little short of a disaster. Yet official reports speak of it again and again as a matter for congratulation. Sir Bamfylde Fuller was nearer the mark when he wrote in 1889 that "money is practically never raised for the improvement of estates, and in almost every case the cause of debt has been improvidence and ignorance, pure and simple. In such a case a fall in the value of land as a means of raising money is one of the best

things that can happen." Applied to the Sikhs and Arains of the Punjab this is perhaps an over-statement. Over 14,000 wells, mostly masonry, have been sunk in the last five years. Several thousand improved implements have been sold, large tracts of waste land have been broken up, and there is evidence that in the more progressive districts the rudiments of improved agriculture are at last being grasped. But when all is said and done the money spent in this way probably represents but a very small part of the amount borrowed. While 14,000 wells have been sunk there has been an increase of 40,000 suits many of which must have cost the litigant much more than the price of a new well. With a person so incurably litigious as the Punjabi, it may be safely asserted that a substantial part of the money raised on the inflated value of land has been spent in the law courts. In the Civil Justice report of 1913, the increase in the number and value of land suits in Gujranwala is definitely ascribed to the cupidity aroused by the rising value of land. The same report states that in Jullundur practically every alienation is challenged, and the local District Judge adds expressively "the courts are the Monte Carlo of the peasant." That the connexion between debt and litigation is close is shown by the fact that year after year more suits are instituted in Muzaffargarh, Gurdaspur and Sialkot, which are probably the three most heavily indebted districts in the Punjab than in almost any other district in the province. Hoshiarpur and Amritsar run them close, and both are more heavily mortgaged than most districts. There can be no doubt that debt often follows litigation, and in the Punjab it looks as if litigation followed credit, the one increasing as the other expands.

Another common source of debt is ceremonial expenditure, especially of course upon marriages. It is difficult to collect statistics to prove this, but most cultivators will tell you that marriage costs more than it did. Twenty years ago, a peasant proprietor could get married for Rs. 100. Now Rs. 400 or Rs. 500 will hardly cover it, while amongst the Sikhs of the central districts, where the rise in indebtedness has been most marked, it will cost from Rs. 1,000 to Rs. 2,000. I know of a Zilahdar who, though Rs. 6,000 in debt,

spent Rs. 5,000 on a daughter's wedding. And last cold weather I came across a member of a co-operative society, who in 1916 spent Rs. 1,300 in marrying a son and the following year Rs. 400 in marrying a daughter. Together the two sums represented 17 years' rental of his ten-acre holding. And at the time he already owed over Rs. 1,500, most of which he had borrowed for a case. Instances of this kind are probably not uncommon, and they have doubtless multiplied since women became fewer than men. In short, borrowing for unproductive purposes is far too common in India.

We have now examined each of the seven causes to which the increase in indebtedness in the Punjab may be due. Superficial as the survey has been, certain tentative conclusions emerge. In the first place two factors stand out prominently, the great expansion of credit and the rise in prices. The former has probably operated throughout the province, the latter wherever holdings are small. Secondly, with these two main causes are interwoven others the precise importance of which it is difficult to determine as they vary in effect from district to district. Lastly, it is clear that further enquiry is needed, and it should be detailed and systematic. Prosperity and debt are evidently intimately connected; and some of the accepted views in regard to the former would appear to need revision. If this is so, important consequences follow. One is that credit must be controlled. With a simple, uneducated and naturally improvident peasantry, it is clearly dangerous to let people borrow as they please. As a servant credit can turn sand into gold, but as a master it will turn gold into sand. Restriction, therefore, is necessary and co-operative credit is the obvious way of applying it, for members of a co-operative society cannot borrow at will. Moreover, through their society they learn the all important lessons of punctual repayment, honest dealing and thrift. Co-operation is indeed the very negation of indebtedness. In the Jullundur District I calculate that ten years of co-operation have reduced the net indebtedness of 20,000 members by 25 lakhs. No effort, therefore, and no expense should be spared to extend co-operative credit to every village that can be induced to accept it. Incidentally too co-operation is the best remedy for high prices.

Underlying the whole question of indebtedness in the Punjab is the problem of small holdings. We have seen that they are getting smaller and that this process is likely to continue, that they cannot resist bad seasons and suffer from high prices, and that in stimulating a demand for land they lead to its purchase on credit at an inflated value. The evil is clear but the remedy is difficult. The laws of inheritance can hardly be changed, nor is the Punjab well adapted to industries which would provide a subsidiary means of subsistence. The latter indeed need not be regretted, for no one who is acquainted with industrial conditions in India could wish the relatively healthy life of a country to be exchanged for the demoralizing influences of the town. There remain only two remedies: one is the improvement of agriculture so that production may keep pace with population, and the other is the encouragement of emigration. A good start with the former has been made by the Agricultural Department, but India is still far behind America and Western Europe in the effort made. Moreover, there are limits to what can be done, as small holdings and advanced agriculture do not agree very well together; and in India the difficulty is accentuated by the climate which saps all desire for improvement. The alternative remedy, emigration, is therefore important. Before the war the Punjabi was more and more going to America and the Far East, and though he often returned a wealthy man—some have brought back nearly a lakh—he was not always a better man for the change. The war has happily provided an ideal colony for the future. In Mesopotamia, with its somewhat better climate than the Punjab, the sturdy qualities of our peasant proprietors should reach their fullest development. It is to be hoped, therefore, that this will not be lost sight of in the reconstruction that will follow peace with Turkey. The rural Punjab deserves well of its rulers; and as the only martial province in India, anything that threatens its welfare is of more than usual importance. At present it is undoubtedly prosperous, but prosperity has brought debt. This anomaly should, if possible, be removed.

THE WHEAT PESTS PROBLEM.*

It is now well recognized that scientific research is of great money value, but it is not often that successful practical results follow so quickly upon research as in the recent campaign against the insect pests in the vast quantities of wheat which, owing to the war, accumulated in Australia. In this campaign, South Australia played a very important part.

In the early stages of the weevil plague, at the instance of Mr. G. G. Nicholls, Manager of the South Australian Wheat Scheme, a Wheat Weevil Committee was appointed consisting of Dr. W. A. Hargreaves, Director of the South Australian Department of Chemistry (Chairman), Mr. G. G. Nicholls, Mr. W. J. Spafford (Superintendent of Experimental Work, Department of Agriculture), Mr. A. M. Lea (Entomologist to the S. A. Museum), Mr. E. A. Badcock (Manager, S. A. Farmers Co-operative Union, Ltd.), and Mr. J. T. Jackett (Miller). Subsequently Mr. D. C. Winterbottom (Supervisor of Weevil Department in S. A. Wheat Scheme) was added to the Committee.

The work of scientific research on the subject was taken up by the Department of Chemistry, and from experiments conducted in the laboratory of that department three practical systems of treatment were devised. These, when put into use by the Wheat Boards in the States of South Australia, Victoria and Western Australia, resulted in saving wheat worth at least £ 1,500,000, besides giving very valuable knowledge on the whole problem of stored wheat which will be of service in the future.

This estimate of monetary value is an approximation. It is, however, based on the observation that the actual weevil damage

* **Extracted from Report No. 2 of the State Advisory Council of Science and Industry of South Australia.**

was at least reduced to one-half of what it would otherwise have been. Senator Russell, Chairman of the Australian Wheat Board, announced, on January 10th, 1920, that the actual weevil damage done to the wheat purchased by the British Government during the time it was held after purchase and before shipment had been assessed at 2,200,000 bushels, and that the British Government had agreed to pay the Australian Wheat Board the sum of £ 522,000 to cover this loss. This was based on the contract rate of 4*s*. 9*d*. per bushel. The amount paid for losses can be taken as a low estimate of the value of the wheat saved for the British Government. During the three years 1915-16, 1916-17, and 1917-18, the Commonwealth production of wheat was 404,000,000 bushels, of which South Australia contributed 98,000,000 and Victoria 136,000,000 bushels. The British Government contract was for 112,000,000 bushels, of which South Australia supplied 36,000,000 and Victoria 40,000,000 bushels, so that in round figures the British Government took about one quarter of the Commonwealth output, and this entailed about one-third of the output of South Australia and Victoria. The savings to each of the States of South Australia and Victoria can be taken then to be at least an equal amount to that saved for the British Government. Hence we arrive at the conservative estimate of £ 1,500,000 worth of wheat saved from destruction as the result of scientific research.

The following figures may help to demonstrate the extent of the undertaking as it affected South Australia, where the wheat had to be safeguarded from mice, weevils, etc.

The crop carried over from 1917-18 and in stacks was 42,000,000 bushels. The 1918 crop was 26,000,000 bushels, making a total of 68,000,000 bushels on hand. During the twelve months following only about 11,000,000 bushels were disposed of, leaving nearly 57,000,000 bushels to be carried over to 1918-19. The 1919 crop was over 20,000,000 bushels, and left no less than 77,000,000 bushels to be guarded.

Some idea of the magnitude of the work can also be gained from the following remarks made by Mr. R. A. Love, who was the

Australian Commissioner for the Royal Commission of Food Supplies in London :—

"The cleaning, sterilizing, and handling that had to be undertaken in Australia in connection with the wheat was without doubt the largest campaign of its sort that the world has ever had to undertake. When one considers the enormous amount of labour and the handling involved to enable the vast quantities to be cleaned, sterilized and made fit for shipment, it was truly colossal. In looking back over the work I think we can be proud of the results of our labours. It is nice to feel, considering the enormous amount of thought and worry put into the task, that it was successful in results, efficiency and cost.

"The gassing campaign without doubt saved an enormous amount of money, and enabled vast quantities of wheat to be held over until they could be treated."

The methods recommended by the Wheat Weevil Committee, as the result of the scientific research carried out by the Department of Chemistry, were the following :–

1. *Cleanliness.* The weevil was recognized as a pest which was fostered by careless and dirty conditions. Cleanliness in the collection, transport and storage of the wheat was, therefore, advocated. In storage the chief problem was to prevent contamination of the stacks from without. Hence the following precautions were enjoined :—Absolutely clean stacking sites, impervious insect proof floors, thorough cleaning up of old stacking sites, and gutters filled with water, oil, or molasses placed around the base of the stacks to prevent access of crawling weevils. Stacks were either enclosed in hessian and then limewashed or wherever practicable entirely enclosed in malthoid sheds. The malthoid sheds, first tried at the suggestion of Mr. A. M. Lea, a member of the Wheat Weevil Committee, proved the most successful.

2. *Gas treatment.* The use of poison gas for the extermination of vermin is by no means a new idea, and as far back as 1890 gas plants were used in South Australia for the purpose of suffocating rabbits in their burrows by means of air deprived of its free oxygen by being passed through a fire. During the mouse plague of 1916-17,

Dr. Hargreaves had suggested the use of a gas producer plant for providing large quantities of cheap gas for the extermination of mice, and in the middle of 1917, Mr. Saunders of Clutterbuck Bros., of Adelaide, experimented with producer gas as a means of destroying weevils, but these initial experiments were unsatisfactory, because the treatment was not continued nearly long enough. Carbon dioxide compressed in cylinders had been advocated in 1898 by Noel Paton, and in 1911, 1912 and 1913 by Barnes and Grove, but their methods were prohibitive on account of cost. It was not until the time factor was shown to be an important one, by experiments with weevils in closed bottles, carried out in January 1918 by Mr. Spafford, a member of the Committee, that gas treatment was found effective.

Mr. D. C. Winterbottom, Chemist in the Department of Chemistry, was transferred to the South Australian Wheat Scheme as officer supervising weevil destruction, and he installed the first gas plant in Australia. It was a decided success. Subsequently, other plants were installed by him in South Australia and Victoria, and similar plants were used in Western Australia. The operation of these gas plants in South Australia was placed in the hands of Messrs. S. D. Shield and E. A. Pengelly, research chemists of the Department of Chemistry, and in Victoria the plants were in charge of Mr. P. J. Thompson, of the Melbourne University.

The method employed was as follows :—The stacked grain was entirely enclosed in sheds covered with malthoid or similar material made as nearly air-tight as possible. Then air freed from free oxygen by being passed through a furnace similar to that of a gas producer, but producing carbon dioxide instead of carbon monoxide, was blown into the shed for three or four weeks to asphyxiate the insects. Many large stacks were thus successfully treated. In one case the stack contained 200,000 bags of wheat.

3. *Heat treatment.* In the cleaning and shipment of the weevilly wheat, heat treatment to a temperature of 140° or 150° Fahrenheit was found to be the most effective method of checking further outbreak of weevil. Soon after research was commenced in August 1917, Mr. Winterbottom found that this would probably

be a successful method, and experiments were made to see the effects of heat treatment on the wheat. It was proved that the flour and bread making properties were not impaired. A machine was invented in the Department of Chemistry and erected at Port Adelaide which killed all the insects passed through it without damaging the wheat. This was the first successful heat treatment plant in Australia.

Professor Lefroy was working on behalf of the British Commission in Sydney, and he investigated a large number of devices for destroying weevils, including a number of heat treatment machines designed by different inventors. He finally adopted the Poole and Steele Machine. At first this machine was not successful, but Dr. Hargreaves was able, as a result of experience gained by the research experiments, to suggest, at a conference in Sydney in March 1918, certain modifications which resulted in the successful working of the machine, which was then adopted by the British Commission.

The effects of this successful end to the investigations will be more far-reaching than they appear at first sight. Not only can the saving of the wheat stored during the war, which would otherwise have been destroyed by insect pests, be directly credited to scientific research, but the results obtained have demonstrated the practical value of the methods used. These methods can be used in future, so that the total money value of the research is beyond assessment.

A NEW PROCESS OF SEED SEPARATION.*

BY

A. EASTHAM,

Chief Seed Analyst, Department of Agriculture, Canada.

A NEW method of cleaning and grading seeds and grain has been invented and patented by Mr. E. D. Eddy, formerly Chief Seed Inspector of the Department of Agriculture, Canada. In the process of separation neither screens nor air currents are used, the separation being made entirely on the basis of comparative specific gravity. This is effected by subjecting the stock being treated to centrifugal action in the presence of a liquid which is of the specific gravity required for the separations desired. The patent claims include the following :—

"The method of separating grain and seeds into two grades or qualities, one lighter and one heavier, on the basis of comparative specific gravity by subjecting the same to a centrifugal action in the presence of a liquid having a density greater than the lighter grade and equal to or less than the density of the seeds or contained material composing the heavier grade ; the density of the liquid to be varied according to the separation desired."

The specific gravity of the liquid is varied according to the comparative weight of the seeds to be separated. A suitable material for making a liquid of the desired density is sodium nitrate but other substances may be used. With seeds weighing about sixty pounds per measured bushel, such as alfalfa and clovers, a solution of about 1·2 specific gravity is required. The best point of density varies with

* Reprinted from *The Agri. Gaz. of Canada*, Vol. VII, No. 11.

different kinds of seeds and the severity of the separation desired. By regulating the density of the liquid the proportion of the seeds which pass into the heavy and light separations is under perfect control. With clover seed, for instance, all weed seeds and other foreign matter, as well as shrunken, immature and light weight clover seeds of a lower specific gravity than the liquid are separated from those seeds which are as heavy as, or heavier than, the liquid. The proportion of clover seeds which will go into the light separation can be accurately regulated according to the character of the sample and the separation required.

The fact that most of the weed seeds commonly found in clover seeds are of a slightly less specific gravity than good clover seeds makes possible some remarkable separations by this process. With the ordinary methods of cleaning it is impossible to make a thorough separation of weed seeds from clover seeds if the former are approximately the same size as the clover seeds and closely similar in specific gravity. Cleaning this type of seed by screens and wind blast is far from thorough and involves a heavy loss of good seed. The advantages of the new process in such cases may be realized from the results of recent experiments made in the seed laboratory. Some of the results were secured with a small experimental machine and others with a machine designed for continuous work on a commercial scale.

Tests of several samples of red clover show a perfect separation of several kinds of the most common weed seeds classed as noxious under the Seed Control Act, including ragweed, Canada thistle, wild mustard, ox-eye daisy and stickseed, while others, such as ribgrass, campions and docks, were materially reduced. One lot of red clover screenings containing about one quarter ragweed seed, hulled and unhulled, was treated, and the cleaned seed was entirely free from ragweed with practically no loss of good seed. Almost equally valuable are the results in reducing the less harmful species including green foxtail which is the most common weed seed in red clover.

With alsike seed, perfect separations were made of false flax, Canada thistle, ox-eye daisy and unhulled timothy seed, while sheep

sorrel, foxtail and lambs quarters were almost entirely eliminated without material loss of good seed.

The results with alfalfa seed were especially promising, for they indicate that it may be possible to remove the weed seeds which have made it very difficult to produce clean seed in Western Canada and the Western States. The most troublesome weeds in alfalfa seed growing in the West are probably Russian thistle, stink-weed and wild mustard. At present it is almost impossible to procure alfalfa seed grown in Western Canada or the North-Western States which does not contain one or more of these weed seeds. Furthermore, in many cases they are present in such large numbers that even after heavy loss in cleaning, the alfalfa seed is almost unmarketable and its production unprofitable. One lot of alfalfa seed containing over two thousand stink-weed seeds per ounce was subjected to the new separation process and the cleaned seed was found entirely free from these weed seeds and there was no loss of alfalfa except a few light and shrunken seeds whose removal improved the sample. Equally good results were shown with a sample containing Russian thistle seed. Wild mustard was also readily separated from alfalfa as well as from the clovers.

In the case of timothy seed most samples consist of both hulled and unhulled seed which interferes somewhat with the removal of the weed seeds. With lots, however, containing only a small percentage of hulled seed some very effective separations of sheep sorrel, lambs quarters and other common weed seeds were made. A separation of perhaps more value for laboratory purposes than for commercial work is that of hulled from unhulled timothy seed. Numerous tests with different percentages of hulled seed showed perfect separation. That this separation is possible is evidence of the accuracy of the process in dividing samples on the specific gravity basis.

Tests so far made have been mostly with small seeds. It is expected, however, that valuable results will be secured also with grains by removing barley and oats from wheat, oats from barley, etc., in addition to the separation of weed seeds.

The process is, we understand, now being developed with the idea of putting it on a commercial basis. Should this be accomplished and the results obtained with seeds cleaned for general commerce be equal to those shown in the experimental tests, there should be a great improvement in the purity and general quality of the seed available, and the seed growing possibilities both for small seeds and seed grain will be greatly increased.

Notes

A SIMPLE POLLINATING APPARATUS.

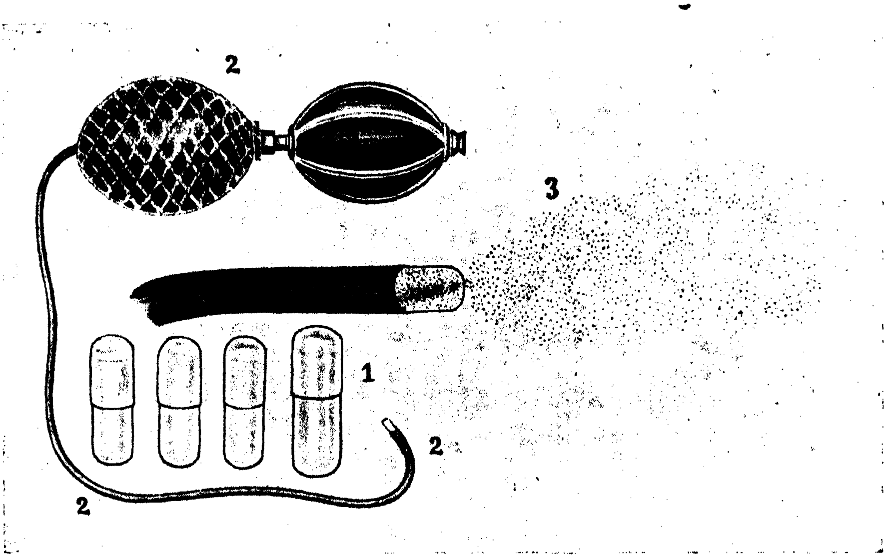
With the increasing recognition of the value of cross-pollination as means of producing superior strains of agricultural crops, repeated attempts are continuously being made to simplify the manipulations involved in the process. The "Botanical Gazette," for July 1919, describes an apparatus invented by Mr. Marie C. Coulter, of the University of Chicago, under the title "A Corn Pollinator."

The writer has been using, with considerable success and for over five years, an apparatus of his own design in the cross-pollination of sugarcanes at the Sugarcane-breeding Station, Coimbatore, and, as this would appear to possess certain distinct advantages, it is described below.

The pollen intended for crossing is collected from flowers bagged the previous evening, or early the same morning long before the anthers burst and shed the pollen. Tissue paper bags are used for the purpose. The collected pollen is passed through fine-meshed wire-gauze which would just allow the pollen to get through and free it from pieces of broken anthers or stigmas, often inevitable in such collections.

This sieved pollen is subsequently loaded into gelatine capsules (Text-fig., 1) available at any druggist's, where it is used to administer unpalatable medicines. Such capsules used to be available pre-war at twelve annas a hundred and are now to be had at twice the price. A slight moistening of the outer edge of the lower half, before the insertion of the lid, fastens them together and removes all risk of the pollen getting spilt in the subsequent handling. These are now treated as so many loaded cartridges and have been found very convenient to handle.

The arrow (sugarcane flower) to be cross-pollinated is now selected, the pollen-charged capsule inserted at the tube end of a "blowing ball" (Text-fig., 2), and two holes, one at the anterior



1. Gelatine capsules available at any druggist's for storing pollen.
2. A "blowing ball" showing the insertion of a pollen charged capsule at its tube end.
3. Showing the gentle spray of pollen as it emanates from the free end of the gelatine capsule when the blowing ball is operated.

and a second at the posterior end of the capsule, are made with one operation by passing a darning needle through, taking care not to puncture the india-rubber tubing in the process. When the bulb of the "blowing ball" is operated, a gentle spray, much like what happens in Nature when a sugarcane arrow is shaken by the wind or gently tapped, is given out at the free end of the capsule and can be directed to any portion of the arrow as desired. (Text-fig., 3.)

In the experience of the writer the following advantages have been noticed in favour of the apparatus described above :—

(1) The pollen spray is very gentle and closely resembles what takes place in Nature. The gentle spray conduces to economy of pollen, a great desideratum in the cross-pollination of sugarcanes.

(2) There is no risk of breakage and, as the capsules are sufficiently cheap to be thrown away each time after

use, there is no chance of a mix-up of different pollens at the time of crossing.

(3) No clogging is experienced in any portion of the apparatus, as the pollen is previously sieved.

(4) There is no risk of a blow back of the pollen, as the valve in the "blowing ball" allows the movement of air only in one direction, *viz.*, away from the free end of the capsule.

(5) Till the time it is actually needed, the pollen is stored away in what to all practical purposes are sealed receptacles, which minimizes chances of mistakes.

(6) The same apparatus can be used for a large number of cross-pollinations; all that is needed being a washing of the insertion end of the rubber tube, should any pollen be noticed at that end, whenever a fresh kind of pollen is used. This is rarely necessary if the operations are conducted with a certain amount of care and neatness.

(7) The height at which a particular pollination has to be done presents no special difficulties, as the outfit is light and compact. Sugarcane pollination has often to be done at a height of not less than 12 feet.

It should be mentioned, however, that, in very moist or dewy weather, the gelatine capsules become soft and the spraying becomes impossible. For the same reason the pollen, before loading, should be carefully freed from any adhering moisture, a usual condition when pollen has to be collected after rainy or dewy nights.

In all cross-pollination work it is essential that the pollen should be frequently and repeatedly tested for viability; as the conditions of storage, for however brief a period, or the inevitable manipulations, however carefully done, often greatly diminish or altogether destroy its vitality. It is reported that barley pollen loses its viability in about ten minutes in free air.

The artificial germination of pollen often presents considerable difficulties, and the interesting discovery has recently been made

that sugarcane pollen germinates freely on the stigmas of *Datura fastuosa* var. *alba*. This has rendered possible a series of experiments on the relative merits of different methods of storage of sugarcane pollen; and it has recently been found possible to keep sugarcane pollen viable for over seven days by preventing the dehiscence of the anther sacs. [T. S. VENKATRAMAN.]

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A VALUABLE CATTLE FODDER.

THE following further Bulletin on the usefulness of *baisurai* (*Pluchea lanceolata*) as a cattle fodder, by Dr. A. E. Parr and Babu Puttoo Lal, is being issued by the U. P. Department of Agriculture :—

Baisurai or *roshna* (*Pluchea lanceolata*) is a very troublesome farm weed in many parts of the United Provinces. It is particularly well known in the Agra Division and also occurs over large areas in the districts of Jaunpur and Benares. In the hot weather months, after the *rabi* crops are cut, it is so abundant as to appear like a crop on the ground. It is pre-eminently a weed of dry tracts as a deep root system enables it to live and thrive in the dry months when less deep-rooted plants die for want of moisture.

It has a peculiar taste, and on this account cattle carefully avoid it when grazing.

Experiments were begun some time ago to see if some use could be made of it as cattle fodder. A short account of the early results obtained by feeding a mixture of *bhusa* and *baisurai* at the Agra district farm has already been published.[1] Further experiments have been carried on at the Aligarh experiment farm. They have yielded very useful practical results, details of which will be found below.

The chief cattle fodder of a great part of the United Provinces, from the beginning of November until the *rabi* crops are harvested and threshed, consists of the dry stalks of *juar* (*Sorghum*). This does not form an ideal fodder. It is coarse and hard even soon after it is harvested and becomes more so after a few months of

[1] *The Agri. Journ. India*, XVI, Pt. 1, p. 106.

storage. It contains only a small percentage of protein and has a large amount of indigestible ingredients. Analyses of *baisurai* show it to have a fairly high percentage of protein or flesh-forming material.

Experiments have now been carried on at Aligarh to see if young green *baisurai* would not be a valuable addition to dry *juar* stalks. The experiments have now been in progress for more than two months and have yielded very interesting results.

Seven bullocks were used for the experiment. Three of these were fed on *juar* stalks only. The other four were given a ration made up of half green *baisurai* and half *juar* stalks. Each bullock was fed separately and each animal got all the fodder he cared to eat. Each bullock was weighed daily and was given fairly regular work. The experiment began on the 1st November and the last weighing given in this note was made on January 6.

The weights of the various bullocks at the beginning and end of the experiment are given below :—

Name of bullock	Kind of fodder	Weight on 1st November	Weight on 6th January	Difference
		Mds. Srs.	Mds. Srs.	Srs.
Bissa wala A ..	*Juar* only	10 19	9 25	—34
Bissa wala B ..	Do.	10 29	10 22	—7
Atrauli A ..	Do.	7 3	6 33	—10
Atrauli B ..	*Baisurai* and *juar*	7 31	8 2	+11
Kishen Singh wala A ..	Do.	9 31	9 39	+ 8
Kishen Singh wala B ..	Do.	10 6	10 25	+19
Naubat wala ..	Do.	10 6	10 14	+ 8

It will be seen from the above table that in every case animals fed on *juar* fodder alone lost weight, while those fed on *juar* and *baisurai* gained in weight.

The figures indicate emphatically the value of the *baisurai-juar* mixture. But to any one experienced in animal management

the present condition of the bullocks themselves is even more striking. The animals fed on the mixture have a sleek well fed appearance. Those fed on *juar* alone have the staring dull coats which are always associated with animals not in a thriving condition.

Owing to the failure of the rains, fodder is very scarce this year, and there will probably be something approaching a fodder famine in some of the drier districts.

In the *baisurai* tract of the Agra Division alone, there are about 150,000 working bullocks. These could be fed on a quantity of green *baisurai* each day with a corresponding reduction of *juar* fodder, and probably later on of *bhusa*. During the next six months, that is during the period that fodder is likely to be scarce, in this tract alone *baisurai* could replace two million maunds of ordinary village fodder. This at present prices would mean a saving of roughly one-and-a-half million rupees.

The Agra Division instead of being short of fodder would have a surplus for sale elsewhere.

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PRICKLY PEAR AS FODDER FOR MILCH CATTLE

In India, prickly pear is not ordinarily used as a cattle food, but only during periods of famine when no other fodder is readily available. The cactus is roasted over a village forge and chopped fine before being given to the cattle in combination with *kadbi* (dry *Sorghum* stalks) or cotton seed. It will be remembered that during the last fodder famine in 1919 in the Bombay Presidency at one time as many as 34,000 cattle were feeding on this preparation in the district of Ahmednagar alone. In reviewing the work of cactus "kitchens" maintained by Government for famishing cattle, Lieut.-Col. G. K. Walker, Superintendent, Civil Veterinary Department, Bombay, remarked that "there can be no doubt that cattle can be maintained on prickly pear, when necessary, without harm." It, however, appears from the following extract taken from the "Journal of the Department of Agriculture, Union of South Africa" (Vol. I, No. 9), that prickly pear is not merely an emergency fodder, but is considered a valuable foodstuff for milch cattle which increases

the " quantity while maintaining the quality of the milk." " In Corsica and Sardinia, a daily ration of about 50 or 60 lb. per cow, comprising prickly pear finely cut up, mixed with bran or dry grass, was fed to impoverished cows, which had almost ceased their supplies, with good results. Mr. Martin, whose experience in feeding prickly pear to oxen has been quoted above, found his milk supply greatly augmented by utilizing prickly pear as a feed for his milch cows. In Mexico, milch cows maintained their yields, in spite of the increasing coldness of the season, when fed on prickly pear, thus minimizing the need of purchasing expensive winter fodders." [EDITOR.]

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THE MANURIAL VALUE OF COTTON BUSH.

THE following notes by the Acting Assistant Chemist of the Agricultural Department, St. Kitts-Nevis, are reproduced from the report on the Agricultural Department of that Presidency for the year 1918-19. The results of the experiments undertaken by Mr. Kelsick seem to justify his conclusion that the practice of burning cotton plants left on the land after picking the cotton is unadvisable, except for special reasons relating to the control of insect or fungus pests.

The practice of burning the remains of cotton plants left on the land after reaping has been, and still is, a general one in the cotton-growing islands in the West Indies, with the exception of St. Kitts where the bushes have always been buried under the banks.

The reason for burning, which is enforced by law in all West Indian cotton-growing islands, except St. Kitts and Nevis, was the eradication of insect and fungus pests, but in a paper by the Agricultural Superintendent, St. Kitts-Nevis, " Notes on the destruction of cotton bushes by burning " (*West Indian Bulletin*, Vol. XV, p. 319), it was pointed out that at La Guerite Experiment Station, where cotton was grown continuously, burying the bushes had been done instead of burning for some years with no increase of disease, and a change from burning to burying was strongly advocated.

The following notes have been written to show to what extent the fertility of the soil is being depleted in those islands where cotton bush is destroyed by burning.

In 1918, the bush remaining on the no-manure and pen-manure plots of the cotton manurial experiments was weighed after the crop had been reaped, with the following results:—

	No-manure lb.	Pen-manure lb.
Series 1	159½	234½
„ 2	148	254
Mean	153½	244½
Per acre	6,140	9,780

This amount of organic material might be considered small, but in tropical countries where the decay of organic matter is very rapid, and the supply of organic manures usually inadequate, any material which will help to maintain the humus content of the soil is valuable. It will, therefore, be seen that by burning the bushes there is an appreciable loss of useful material every year.

The amounts of nitrogen, phosphoric acid, and potash present in an average sample of this material was determined, and the following figures obtained:—

Nitrogen	2·16 per cent.	
Phosphoric acid	1·40 „ „	(on air-dry material)
Potash	2·35 „ „	

These figures show that the bush has a high manurial value, and although some consideration must be given to the fact that it is returned to the land in a very undecomposed state, yet its value as a supply of potential plant food cannot be questioned.

The amount of manurial constituents removed annually from land yielding at the rate of 1,000 lb. of seed-cotton per acre would be about as follows:—

Nitrogen	26·32 lb. per acre.
Phosphoric acid	12·67 „ „ „
Potash	11·96 „ „ „

In computing these figures, use has been made of the figures given in the "West Indian Bulletin," Vol. V, for the composition of Sea Island cotton-seed.

The amount of manurial constituents returned to the soil by burying the remains of the plants would be about as follows:—

Nitrogen	... ...	171·9 lb. per acre
Phosphoric acid	... ...	111·44 „ „ „
Potash	... ...	187·1 „ „ „

It will, therefore, be seen that the amounts of nitrogen, phosphoric acid, and potash returned to the soil by burying the old plants are greatly in excess of those removed in the seed and lint.

Consideration of the foregoing facts makes it evident that the practice of burning the remains of cotton plants is detrimental to the fertility of the land. In the first place there is the loss of an appreciable amount of organic material, so essential for maintaining the fertility of tropical soils; and secondly, the land is deprived of a valuable supply of nitrogen.

The continuation of the practice must eventually lead to a state of unproductiveness, especially in the case of light soils, unless ample supplies of organic manures are available. [*Agricultural News*, No. 475, dated 10th July, 1920.]

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A NEW CANE-CUTTER.

A NEW cane-cutter, invented by Mr. John A. Paine, of the United Fruit Company's factory at Preston, Cuba, has recently been tested in Cuba with, it is said, satisfactory results.

The machine is of a large tractor type, weighing between 5 and 6 tons, and is propelled by gasolene-driven motor. It is capable of maintaining a speed of 6 miles per hour under favourable conditions. The inventor claims for it a capacity of cutting and handling 60 tons of cane per hour. The cutting is done by a 24-in. circular saw, fitted to a revolving shaft at the head of the machine and driven by a motor which is controlled by one man, who can adjust the position of the saw too high or low, to suit cutting conditions as desired. The harvesting arrangement provides for a series of grips which automatically catch the cane as it is being cut and remove the leaves by a stripping process, thence dropping the

stalks of cut and trimmed cane to a conveyor which carries them back and drops them to trailer cars following and drawn by the tractor. The automatic grips will work along the side of an extension and ahead of the cutter and following one row of cane, but in this first test of the machine these parts were not fitted, nor was the conveyor, so this article will not attempt to deal with the possibilities of these added harvesting improvements.

When it is considered a good day's work for one man to cut cane at the rate of 3 to 4 tons per day, it will be obvious, says the "Cuba Review" (to which the "Circular" is indebted for this information), that the economy and added production secured by this two-man cutter and harvester will be enormous, if it is finally proven to be the success now expected of it. The cutting principle is regarded as sound, and it was demonstrated without question that the saw will cut the cane at the level of the ground. [*The West India Committee Circular*, No. 576, dated 28th October, 1920.]

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GERMANS INCREASE CROPS BY FERTILIZING THE AIR.

THAT plants, through their leaves, feed upon the carbonic acid of the atmosphere, besides other elements taken up out of the soil, has long been known. But while the plant physiologists have hitherto studied the problem of increasing the production of crops by applying fertilizers to the soil, they have never thought it possible to get larger yields by fertilizing the air.

But that this latter is possible has been fully proved during the last three years by certain German chemists. Starting with the known fact that the carbonic acid contained in the air is slight—the average is said to be only 0·03 per cent.—they concluded that a considerable addition of that gas to the atmosphere should increase the growth in plants. They made experiments in that direction which are now described by Dr. F. Riedel in "Stahl und Eisen," the organ of the German iron industry.

It was well known to chemists that enormous quantities of carbonic acid are discharged from blast furnaces. But it is full of impurities. In particular it contains sulphur, and it has long been

observed that fields adjacent to blast furnaces bear poor crops as a consequence.

The chemists at one of the large German iron companies in the Essen district accordingly made experiments with gas purified of sulphur and duly diluted with air. Beginning in 1917, they used this purified carbonic acid in greenhouses, where it was distributed through punctured pipes.

The results were remarkable. Even after a few days the plants treated with gas showed a more vigorous growth than those in an adjacent greenhouse. They began to blossom earlier and their general development was much greater. The yield of tomatoes was increased 175 per cent. and cucumbers 70 per cent. At the same time experiments also were made in the open air on square plots around which punctured tubes were laid. Here an increase of 150 per cent. in yield of spinach was reached, 140 per cent. with potatoes, 134 per cent. with lupines (a legume), and 100 per cent. with barley.

Encouraged by these results, the chemists repeated the experiments in 1918 on a much larger scale, using a plot of 30,000 square meters. This time they got an increase of 130 per cent. with tomatoes, and even 300 per cent. with potatoes.

Other experiments proved that this fertilization of the air is far more effective than that of the soil, even though the latter be on a liberal scale. Fertilizing the soil alone gave an 18 per cent. increase; but soil and air fertilization together gave an 82 per cent. increase. The chemists do not regard the use of carbonic acid gas as a substitute for soil fertilization, but as an addition to it; both are necessary.

It is believed that this discovery will lead to very important results; it should make every agricultural region adjacent to furnaces enormous food producers. Dr. Riedel points out that a battery of furnaces producing 1,000 tons of pig iron a day consumes 1,100 tons of coke; also that the carbonic acid gas contained in the fumes from that coke could produce 4,000 tons of vegetable substance like potatoes, if it could be fully utilized. Of course, it cannot be fully utilized; but even if so low a figure as 10 per cent. of it can be

regularly converted into crop products this would be a result well worth striving for.

The discovery opens up a great possibility. May not the time come when from every blast furnace will radiate lines of piping for miles into the surrounding country? Each farmer will then make his contract with the furnace to "turn on the gas" just as in the present irrigation regions water contracts are made. Of course, the gas must not be turned on too strong, for then it would injure the health of the farm labourers; but, fortunately, it is not necessary to fertilize the air so strongly as to injure health. The danger point to health is considerably higher than would be required to insure a great increase in crops. [*Times-Pica-Yune*, dated 17th October, 1920.]

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LESS SEED: LIGHTER MANURING: GREATER YIELD.

A Paris correspondent of the "Manchester Guardian" states that considerable attention has been attracted to the agricultural methods of a farmer (M. Pion Gaud) in the province of Dauphine. It is asserted that were this farmer's methods adopted two-thirds of the grain now sown could be saved, which alone would be a saving of 4,000,000 quintals of cereals. In addition, there would be produced a further 20,000,000 quintals in France, if it can be shown that the method really gives the results claimed. This would enable France to export wheat instead of importing as at present.

The farmer, in describing his experiments, stated that in exhausted soil where in the preceding years oats could not be grown, he used only two-fifths of the quantity of grain that would be put in similar ground which was worked in the usual fashion. He manured with 3 lb. of sulphate of ammonia and 100 lb. of superphosphate, or 100 times less sulphate of ammonia and 100 times less superphosphate than his neighbours. He used no farm manure, and estimated his results at 25 per cent. more grain and straw than was obtained from similar grounds heavily manured and worked differently from his method.

His method of cultivation followed the lines advocated by Jethro Tull of over a century ago. By turning the soil eight or ten times the repeated aeration helped to penetrate the soil with the azote of the air, and so facilitated germination and augmented the production. He ploughed the soil from eight to ten times with a cultivator nearly two yards wide.

Following the lines of an Italian scientist, who is experimenting with the soaking of grain in a special solution which impregnates them with certain salts, he germinated the seeds in soots and nitrates. After soaking the grain in a solution, he placed it for several minutes in a bath of copper sulphate, the grain afterwards being placed in heaps until the warmth produced the beginnings of germination. It was then sown in lines an inch in depth, the machine sowing the superphosphates at the same time. The result was that immediately the plant took and pushed vigorously.

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DESTRUCTIVE INSECTS AND PESTS ACT.

THE following Notification has been issued by the Government of India in the Department of Revenue and Agriculture:—

In exercise of the powers conferred by sub-section (1) of section 3 of the Destructive Insects and Pests Act, 1914 (II of 1914), the Governor General in Council is pleased to direct that the following further amendments shall be made in the rules published with the notification of the Government of India in the Department of Revenue and Agriculture No. 13-C., dated the 7th November, 1917, namely:—

1. In rule 5 of the said rules, for the words "*Fomes semitostus* and *Sphœrostilbe repens*" the words "*Fomes semitostus, Sphœrostilbe repens* and *Fusicladium macrosporum*" shall be substituted.

2. In rules 7 and 9 of the said rules, after the word "Coffee" the words "and Hevea rubber" shall be inserted.

PERSONAL NOTES, APPOINTMENTS AND TRANSFERS, MEETINGS AND CONFERENCES, ETC.

WE deeply regret to record the death of Mr. H. M. Chibber, M.A., Plant Breeding Expert to Government, Bombay, which took place in the evening of Saturday, the 1st January, 1921. Mr. Chibber had specially qualified himself for the post and had made a good start with his work on rice and wheat. His loss is much to be deplored.

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THE New Year's Honours List contains the following names which will be of interest to the Agricultural Department :—

K.C.S.I. THE HON'BLE SIR EDWARD MACLAGAN, K.C.I.E., C.S.I., Governor of the Punjab (sometime Secretary to the Government of India, Revenue and Agriculture Department).

THE HON'BLE SIR NICHOLAS BEATSON-BELL, K.C.I.E., C.S.I., Governor of Assam (sometime Director of Land Records and Agriculture, Eastern Bengal and Assam).

MR. L. J. KERSHAW, C.S.I., C.I.E., Secretary, Revenue and Statistics Department, India Office (sometime Secretary to the Government of India, Revenue and Agriculture Department).

C.I.E. MR. D. T. CHADWICK, I.C.S., Indian Trade Commissioner, London (sometime Director of Agriculture, Madras).

MR. H. C. SAMPSON, B.Sc., Deputy Director of Agriculture, V & VII Circles, Madras Presidency.

DR. E. J. BUTLER, M.B., F.L.S., Imperial Mycologist, Pusa.

Sardar Bahadur. MR. BHAGWAN SINGH, Deputy Superintendent, Civil Veterinary Department, Burma.

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MR. F. J. WARTH, B.Sc., M.Sc., Agricultural Chemist, Burma, has been appointed to officiate as Imperial Agricultural Chemist, Pusa.

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MR. R. SENIOR-WHITE, F.E.S., has been placed on special work at Pusa from 1st November, 1920, to 28th February, 1921, to assist the Imperial Entomologist in sorting the collection of Diptera.

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MR. G. R. HILSON, B.Sc., will in future be designated as Cotton Specialist instead of Economic Botanist for Cotton, Madras.

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DR. R. V. NORRIS, Government Agricultural Chemist and Acting Principal, Agricultural College, Coimbatore, is granted combined leave for nine months.

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MR. G. R. HILSON, B.Sc., Cotton Specialist, Coimbatore, is appointed to act as Principal, Agricultural College, Coimbatore, in addition to his own duties, during the absence of Dr. R. V. Norris on leave, or until further orders.

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RAO SAHIB M. R. RAMASWAMI SIVAN, B.A., Assistant Agricultural Chemist, is appointed to act as Government Agricultural Chemist, Madras, during the absence of Dr. R. . Norris on leave, until further orders.

HIS MAJESTY'S SECRETARY OF STATE has been pleased to appoint Mrs. Dorothy Norris as Government Bacteriologist, Madras.

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MR. R. W. LITTLEWOOD has been appointed Deputy Director of Agriculture, Livestock, Madras, *vice* Mr. A. Carruth, resigned.

***

MR. W. J. JENKINS, who has been appointed Deputy Director of Agriculture, Bombay, has been placed temporarily in charge of the post of Plant Breeding Expert, *vice* Mr. H. M. Chibber, deceased.

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MR. P. J. KERR, M.R.C.V.S., Superintendent, Civil Veterinary Department, Bengal, is appointed to act as Second Imperial Officer, Bengal Veterinary College, in addition to his own duties.

***

THE University of Cambridge has conferred the degree of Sc. D. on Mr. H. M. Leake, who has also been appointed a member of the United Provinces Legislative Council.

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THE HON'BLE Dr. H. M. LEAKE, Director of Agriculture, United Provinces, has been granted combined leave for one year.

***

MR. G. CLARKE, F.I.C., Agricultural Chemist, United Provinces, is appointed to officiate as Director of Agriculture, *vice* the Hon'ble Dr. Leake on combined leave.

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MR. T. R. LOW has been appointed Deputy Director of Agriculture, United Provinces.

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MR. W. N. HARVEY, M.S.E.A.C., Deputy Director of Agriculture, United Provinces, has been granted an extension of leave for two months on medical certificate.

CAPTAIN W. H. PRISTON, F.R.C.V.S., has been appointed to the Indian Civil Veterinary Department, and posted to the United Provinces.

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MR. C. A. MACLEAN has been appointed Deputy Director of Agriculture in Bihar and Orissa, and placed under training at Sipaya.

***

MR. D. P. JOHNSTON has been appointed Deputy Director of Agriculture, Tirhut Circle, Bihar and Orissa, and posted at Sipaya.

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MR. A. P. CLIFF has been appointed Deputy Director of Agriculture, Chota Nagpur Circle, Bihar and Orissa, and posted at Ranchi.

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MR. G. C. SHERRARD, B. A., has been appointed, on return from leave, Professor of Agriculture, Sabour College, Bihar and Orissa.

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MR. N. S. McGOWAN, B. A., Professor of Agriculture, Sabour College, has been appointed Deputy Director of Agriculture, Bhagalpur Circle, Bihar and Orissa, and posted at Sabour.

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MR. H. W. BLAKE has been appointed Agricultural Engineer, Bihar and Orissa, with headquarters at Sabour.

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DR. P. E. LANDER and MR. H. R. STEWART have been appointed Deputy Directors of Agriculture in the Punjab, and have been posted to the Agricultural College, Lyallpur, for training.

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MR. T. A. MILLER BROWNLIE, Agricultural Engineer, Punjab, has been granted furlough on medical certificate for six months.

CAPTAIN U. W. F. WALKER,* Professor of Surgery, Punjab Veterinary College, Lahore, is appointed Professor of Sanitary Science, in addition to his own duties, relieving Captain K. J. S. Dowland, who has been posted under the Superintendent, Government Cattle Farm, Hissar, for training.

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CAPTAIN E. SEWELL, Post-Graduate Professor, Punjab Veterinary College, Lahore, has been attached to the office of the Chief Superintendent, Civil Veterinary Department, Punjab, Lahore, for training.

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THE LIEUTENANT-GOVERNOR OF BURMA has accepted the resignation of his appointment tendered by Mr. E. Thompstone, B.Sc., Deputy Director of Agriculture, Burma.

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MR. LESLIE LORD has been appointed Deputy Director of Agriculture, Burma, with headquarters at Mandalay.

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MR. J. CHARLTON has been appointed Agricultural Chemist, Burma, with headquarters at Mandalay.

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MR. T. RENNIE, M.R.C.V.S., Superintendent, Civil Veterinary Department, Burma, is appointed Veterinary Adviser to the Government of Burma.

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CAPTAIN ALBERT O'NEILL has been appointed Second Superintendent, Civil Veterinary Department, Burma.

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ON return from leave, Mr. R. G. ALLAN, M.A., has been reposted as Principal, Agricultural College, Nagpur.

ON relief by Mr. Allan, Mr. F. J. PLYMEN, A. C. G. I., Principal, Agricultural College, Nagpur, has been appointed Agricultural Chemist to Government, Central Provinces.

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MR. R. T. PEARL, B.Sc., has been appointed Mycologist to Government, Central Provinces.

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ON relief by Mr. Pearl, the services of Mr. S. L. AJREKAR, B.A., Mycologist to Government, Central Provinces, have been replaced at the disposal of the Government of Bombay.

***

MR. S. T. D. WALLACE, B.Sc., Assistant Director of Agriculture, Southern Circle, Central Provinces, has been appointed to officiate as Deputy Director of Agriculture in the same Circle.

***

MR. R. H. HILL has been appointed Assistant Director of Agriculture, Northern Circle, Central Provinces.

***

MR. J. C. MCDOUGALL has been appointed Assistant Director of Agriculture, Western Circle, Central Provinces.

***

MR. A. G. BIRT, B.Sc., on return from leave, has been appointed Deputy Director of Agriculture, Assam Valley, and posted to Jorhat.

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MR. J. N. CHAKRABARTY has been appointed, on probation, Deputy Director of Agriculture, Assam.

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SECTIONAL MEETINGS OF THE BOARD OF AGRICULTURE being now a recognized part of departmental activities, Entomologists,

Mycologists, and Chemists and Bacteriologists assembled at Pusa for their fourth, third and second sessions, respectively, during the week beginning with Monday, the 7th February, 1921. As on the previous occasion, the meetings were not confined to members of the Agricultural Department, and were largely attended by scientific workers attached to other official and semi-official bodies. Several important subjects were on the agenda, and though the discussions were naturally of an informal character, some important and well-considered resolutions were adopted. The Proceedings will be published in due course and a fuller account given in the next issue of the Journal.

Reviews

Proceedings of the Bombay Provincial Board of Agriculture held at Poona, on the 9th and 10th June, 1920 [Bombay: Government Central Press.] Price, Annas 10.

THE Hon'ble Mr. G. S. Curtis, C.S.I., I.C.S., Member of the Executive Council, Government of Bombay, presided over the meetings of the Board, which were attended by 29 members comprised of representatives of Agricultural, Revenue, Irrigation and Co-operative Departments, and a number of private gentlemen interested in agricultural development. The subjects discussed were :—

(1) A short report of technical results achieved up-to-date by the Agricultural Department.

(2) Programme of cotton improvement as laid before Government by the Director of Agriculture as a result of the report of the Indian Cotton Committee.

(3) The improvement of the manure supply in the intensively cultivated tracts of the Bombay Presidency, including the development of organization for advice as to manuring. The question of freight on manures.

(4) The question of organized attacks on definite plant diseases and of further investigation into them.

(5) The great prevalence of epizootic cattle diseases and the policy which should be adopted in regard to them.

(6) The development of agricultural propaganda and the part which (*a*) the co-operative movement, (*b*) agricultural associations and (*c*) district local boards can take in connection with it.

(7) The lines of development of education in vernacular both specially in agriculture and general in rural areas.

(8) The closer co-operation between the "development" departments (agriculture, co-operation, irrigation, sanitation, education, etc.) of Government and the methods by which it can be secured.

(9) The possibility and utility of establishing divisional boards of agriculture to discuss local problems and to be conducted in the vernacular.

(10) The future organization of the work of the Agricultural Engineer.

(11) The financing of the sale of pure and improved cotton by co-operative societies or otherwise.

Discussions were primarily based on notes on the various subjects submitted by the officers mainly concerned in them, and elicited a number of suggestions which will, no doubt, be of considerable help to the "development" departments (agriculture, veterinary, co-operative, etc.) of the province. On most of the subjects no formal resolutions were passed.

In dealing with the question of freight on manures, the Board unanimously resolved that "the Government of Bombay should be approached to ask Railway Companies to charge minimum rates of freight on the carriage of manures." It is well known that at present the freight is proportionately high in comparison with the cost price of manures, and tends to limit their use. The question of reduction in the freight on manures has, for sometime past, engaged the attention of the Agricultural Department and similar resolutions were passed at the Board of Agriculture in India, 1917, and later on at the First Meeting of Agricultural Chemists and Bacteriologists. 1919, with the result that the Agents of the various railways have been asked by the Government of India to give special consideration to applications by Local Governments for reduced rates.

It was agreed that District Boards of Agriculture should be held in the Presidency in order to bring local problems into greater prominence. [EDITOR.]

(1) Poultry Keeping for Pleasure and Profit AND **(2) Murghion ka Rakh-Rakhaw** (IN URDU) **(How to Keep Fowls).**—By Mrs. A. K. FAWKES, Poultry Expert to the United Provinces Government.

WE welcome in pamphlet form, both in English and Urdu, the very interesting series of 20 articles on poultry farming contributed by Mrs. A. K. Fawkes to the "U. P. Journal." They are written in studiously simple and untechnical language and are illustrated both by photographs and drawings. The pamphlets give instructions and advice on every aspect of poultry keeping which can be followed, without any additional trouble or expense and with much advantage, both by the professional who rears poultry for the market and the amateur who keeps fowls for domestic consumption. We hope the circulation of these pamphlets will achieve the desired result. [EDITOR.]

Correspondence

INFLUENCE OF STOCK ON SCION.

To The Editor,

The Agricultural Journal of India.

Sir,

While reading Mr. S. H. Prayag's article on the reciprocal influence of stock and scion, published in Vol. XV, Part V (1920), of "The Agricultural Journal of India," there occurred to me some points which, I think, might interest the author as well as other readers.

(*a*) The first point is in connection with the grafts between the different genera of the Anacardiaceæ of which he speaks on page 541 of the Journal. I have observed one case in Goa, where mango has been successfully grafted on *Spondias mangifera* (*Ambado*). The fruits of this graft were extremely sour and were, therefore, used only in pickles for which the fruits were much appreciated. I hear people in many parts of Goa also resort to this sort of grafting when they want sour fruits for their pickles. Such a grafted tree is known in Goa as *Amtoh*. As far as my observations go, a mango tree grafted on *Spondias mangifera* becomes dwarfed and short-lived.

In view of these facts, it seems to me that the failure of the grafts between the different genera in the Ganeshkhind Botanical Garden (Poona) was not due to any difference in the physiological activities of plants, but simply due to the fact that Poona has a climate which is not favourable to the grafting of anacardiaceous plants. For, from what I have heard and seen I can say that in Poona the mango grafts even on its different species do not establish as readily as they do in the Konkan or Goa. Again, the other plants of the same order which are mentioned on the same page do not thrive in Poona so well as they do in the Konkan and Goa. Hence

the chief reasons, I am inclined to think, why his attempts to make grafts between different genera of the Anacardiaceæ have met with failure in the Ganeshkhind Botanical Garden, are:

(1) The climate is not favourable for the luxuriant growth of the plants.

(2) The climate is such that even the inter-specific grafting of mangoes has not been very successful.

(3) The experiments made were extremely few.

Hence it will be worthwhile to repeat the experiments in places like Kanara and Goa—localities pre-eminently suited for the growing of anacardiaceous trees and making their grafts.

(*b*) The second point is about the grafting of *Chiku* (*Achras sapota*) on *Ryan* (*Mimusops hexandra*), also mentioned on the same page. There are persons in Bassein and Golwad (Thana District) who believe that the *Ryan*, or *Ranjant* as they call it, exerts an injurious influence on the *Chiku* scion in the direction mentioned by the writer. But my inquiries hitherto made go to show that they have no evidences to back their theory which, as far as I have been able to ascertain, is upheld only by some educated persons. The ignorant cultivators rarely graft *Chikus* and when they do, they do on *Chiku* stocks. Besides, most of those who believe in the above theory have also another one which is the converse of the above; every shy bearing *Chiku* must have been grafted on the *Ranjant*. The only case that they were able to cite in support of their belief was the one cited by Mr. P. G. Joshi, formerly the Curator of the late Bassein Botanical Garden, in "The Poona Agricultural College Magazine" (Vol. VI, Pt. 4). But his observations are not very conclusive since they were made on only one plant which might have been influenced in various other ways.

Hence it will be of extreme interest if Mr. Prayag were to make it clear as to the basis of his following statement: "it has been found by experience in Bassein garden that they (meaning the *Chiku* grafts on *Ranjant*) do not yield more than 15 fruits per tree."

College of Agriculture, Poona:
January 18, 1921.

Yours faithfully,
C. X. Furtado.

NEW BOOKS

ON AGRICULTURE AND ALLIED SUBJECTS

1. The Bases of Agricultural Practice and Economics in the United Provinces, India, by H. Martin Leake, M. A., Sc.D., F. L. S. (Cambridge: W. Heffer & Sons.) Price, 15*s*. net.
2. Lessons on Indian Agriculture, by D. Clouston, C.I.E., M. A., B. Sc. Illustrated. (London: Macmillan & Co.) Price, 3*s*. 6*d*.
3. Weeds of Farm Land, by Dr. Winifred E. Brenchley. Pp. x + 239. (London: Longmans, Green & Co.) Price, 12*s*. 6*d*. net.
4. Manual of Tropical and Subtropical Fruits: Excluding the Banana, Coconut, Pine apple, Citrus fruits, Olive and Fig, by W. Popenoe. (Rural Manuals.) Pp. xv+474+xxiv plates. (London: Macmillan & Co.) Price, 30*s*. net.
5. A Course of Practical Physiology for Agricultural Students, by J. Hammond and E. T. Halnan. Pp. 106. (Cambridge. At the University Press.) Price, 4*s*. 6*d*. net.
6. Text-Book of Pastoral and Agricultural Botany, by Prof. John W. Harshberger. Pp. xiii+294. (Philadelphia: P. Blakiston's Son & Co.) Price, 2 dollars.
7. A Text-Book of Plant Biology, by Prof. W. N. Jones and Dr. M. C. Rayner. Pp. viii+262+vi plates. (London: Methuen & Co.) Price, 7*s*.
8. An Introduction to the Structure and Reproduction of Plants, by Prof. F. E. Fritch and Dr. E. J. Salisbury. Pp. viii + 458. (London: G. Bell and Sons, Ltd.) Price, 15*s*. net.
9. Productive Soils. The Fundamentals of Successful Soil Management and Profitable Crop Production, by W. W. Weir.

Pp. xvi + 398. (Philadelphia and London: J. B. Lippincott Co.) Price, 10*s.* 6*d.* net.

10. A Farmer's Handbook: A Manual for Students and Beginners, by R. C. Andrew. Pp. xvi + 126 + xliv plates. (London: G. Bell and Sons, Ltd.) Price, 6*s.* net.
11. Laboratory Manual of Organic Chemistry, by Dr. H. L. Fisher. Pp. x+331. (New York: J. Wiley and Sons, Inc.; London: Chapman and Hall, Ltd.) Price, 12*s.* 6*d.* net.
12. Agricultural Geology, by Dr. F. V. Emerson. Pp. xviii+319. (New York: J. Wiley and Sons, Inc.; London: Chapman and Hall, Ltd.) Price 16*s.* 6*d.* net.
13. Root Development in the Grassland Formation: A Correlation of the Root Systems of Native Vegetation and Crop Plants, by Prof. J. E. Weaver. Pp. 151+Plates. (Washington: Carnegie Institution.)

The following publications have been issued by the Imperial Department of Agriculture since our last issue:—

Memoirs.

1. Studies in Diseases of the Jute Plant. (1) *Diplodia Corchori* Syd., by F. J. F. Shaw, D.Sc., A.R.C.S., F.L.S. (Botanical Series, Vol. XI, No. 2.) Price, Rs. 2 or 2*s.* 8*d.*
2. Morphology and Parasitism of *Acrothecium Penniseti* n. sp. (A new Disease of *Pennisetum typhoideum*), by Manoranjan Mitra, M.Sc. (Botanical Series, Vol. XI, No. 3.) Price, R. 1-4 or 2*s.*
3. Windrowing Sugarcane in the North-West Frontier Province. Part I.—The Effect on the Economical and Agricultural Situation, by W. Robertson Brown. Part II.—The Effect on the Composition of Sugarcane, by W. H. Harrison, D.Sc., and P. B. Sanyal, M.Sc. (Chemical Series, Vol. V, No. 10.) Price, As. 12 or 1*s.*
4. Life-histories of Indian Insects: Microlepidoptera, by T. Bainbrigge Fletcher, R.N., F.L.S., F.E.S., F.Z.S. (Entomological Series, Vol. VI, Nos. 1–9.) Price, Rs. 7-8 or 11*s.* 3*d.*

Indigo Publications.

1. The Conditions affecting the Quality of the Java Indigo Plant (Leaf Yield and Richness of the Leaf in Indigotin), by W. A. Davis, B.Sc., A.C.G.I. (Indigo Publication No. 7.) Price, As. 9.
2. Note on the Development of the Indigo Industry in Assam in conjunction with Tea and other Crops, by W. A. Davis, B.Sc., A.C.G.I. (Indigo Publication No. 8.) Price, As. 3.

Report.

1. Review of the Agricultural Operations in India, 1919-20. Price, R. 1-4.

THE BLACK-HEADED ORIOLE (*ORIOLUS LUTEOLUS.*

Original Articles

SOME COMMON INDIAN BIRDS.

No. 9. THE BLACK-HEADED ORIOLE (*ORIOLUS LUTEOLUS*).

BY

T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S.,
Imperial Entomologist ;

AND

C. M. INGLIS, M.B.O.U., F.E.S., F.Z.S.

ORIOLES, commonly called " Mango birds " in India, are well-known to all observers of bird life on account of the conspicuous yellow which is the prevailing hue in eight out of our nine different species, the ninth (*O. traillii*) being black and maroon-red. Of the eight species to which the term Yellow Orioles may be applied, only two are common in the Plains of India and these are the Indian Oriole (*Oriolus kundoo*) and the Indian Black-headed Oriole (*O. luteolus*), in both of which species the tail is black and yellow or green but in the former the nape and crown of the head are yellow or greenish-yellow with a small patch of black through the eye, whilst in the latter species these are black, as is the upper breast. Some females are nearly as brightly coloured as the males. Both species are very similar in their habits, being thoroughly arboreal birds, rarely seen on the ground, and feeding mostly on fruit and such insects as are found on leaves and stems.

Cunningham, in his book *Some Indian Friends and Acquaintances*, gives a charmingly written account of the Black-headed

Oriole in Calcutta, in the course of which he says :—" It would be hard to imagine any plumage more beautiful than that of the mature birds with its brilliant contrasts of vivid yellow and shining black ; and though that of the females and young birds is not so striking, owing to the greenish tone and streakiness of the yellow parts, it has very decided beauties of its own in its delicate gradations and pencillings of colour. They have a truly astonishing variety of notes, almost all of them charmingly melodious in character. As a rule, they go about in pairs, who pass from tree to tree ' crying and calling ' to one another at brief intervals. When they are in their very fullest voice the one bird cries, ' Yū, hū a yu,' and the other almost immediately replies, ' Tu hū ēē ' ; when very much out of voice they often can do no more than cry ' Te hēē ' like Alisoun in the *Miller's Tale* ; and between these extremes there is a whole range of very distinct calls that only agree in conveying a sense of joy and fulness of life and melodious contentment with it. All of these are highly characteristic and distinct from the notes of any other kinds of birds, save one or two of the most fluty cries of the common treepies. It is delightful to see any living things so full of the pure joy of existence as a pair of Orioles always seem to be when they come leaping through the air into a garden, calling as they go ; or, after they have alighted in a tree, chasing one another about from bough to bough with their golden plumage shining out among the surrounding green. Now and then a solitary bird will take to haunting a garden for a time, making its appearance regularly day after day at a particular time, in order to visit certain trees and talk softly to itself as it goes on its way ; but it is only when in pairs, or in a small family party of three or four birds, such as may sometimes be seen soon after the nesting season, that they fill the air ' with their sweet jargoning.' The solitary birds occasionally seem to be soured by the want of companionship, and travel round hustling other birds and knocking them off their perches out of gratuitous ill-temper—conduct of which paired birds are never guilty. In addition to the manifold modifications of their regular melodious calls, they sometimes utter harshly cawing notes, and the young birds for a time indulge in churring cries somewhat like those of starlings."

As noted above, the Black-headed Oriole feeds chiefly on fruit and small insects. The late C. W. Mason examined the stomachs of twenty-three birds at Pusa and found that seventeen of these had fed on wild fig fruits and five of these contained nothing else ; the eighteen which had fed on insects contained 95 insects, of which four were classed as beneficial, 73 as injurious and 18 as neutral. Five birds had eaten insects only. In the Central Provinces Mr. E. A. D'Abreu found a Pyralid caterpillar and *Ficus* fruit in the stomach of one bird examined on 24th January 1914. At Pusa also we have watched this bird feeding on masses of a mealy-bug clustered on the stem of a wild vine growing on a *sissu* tree. So far as agriculture is concerned, therefore, this bird may be considered beneficial. It has not been noted to attack cultivated fruits.

Many authors (*e.g.*, Oates and Dewar) note that this bird is strictly arboreal in habits, never descending to the ground ; but it is occasionally seen on the ground capturing insects.

The nest is a cup-like structure which is usually placed in the fork of a branch and lashed in position by means of fibres which are wound first around a branch, then passed under the nest, and then wound around another bough. In the case of the Indian Oriole (*O. kundoo*) Dewar (*Birds of the Plains*, pp. 138-139) notes :—"A very curious thing that I have noticed about the Indian Oriole's nest is that it is always situated either in the same tree as a King-crow's nest or in an adjacent tree. I have seen some thirteen or fourteen Orioles' nests since I first noticed this phenomenon, and have in every case found a King-crow's nest within ten yards. The drongo builds earlier, for it is usually feeding its young while the Oriole is incubating. It would therefore appear that it is the Oriole which elects to build near the king-crow. I imagine that it does so for the sake of protection ; it must be a great thing for a timid bird to have a vigorous policeman all to itself, a policeman who will not allow a big creature to approach under any pretext whatever." The Black-headed Oriole, however, does not seem to have been noticed to have police protection in this manner.

The breeding season of the Black-headed Oriole is from March to August. Both birds appear to take part in the construction

of the nest which is almost always firmly attached to the extreme terminal twigs of an upper horizontal branch of a large tree, some twelve to thirty feet above ground-level. The nest itself is a deep cup, the egg-cavity measuring about three inches in diameter and two inches in depth. It is composed chiefly of tow-like vegetable fibres, thin slips of bark and the like, and is lined inside with very fine tamarisk twigs or thin grass, and on the outside it is generally more or less covered over with odds and ends, bits of lichen, thin flakes of bark, etc. Three eggs are laid as a rule, but occasionally there may be two or four. The egg averages about 28·5 mm. long by 18 mm. broad, the shell fine and moderately glossy, usually creamy or pinky white with sparse spots and streaks of dark brown and pale inky purple.

The Black-headed Oriole has long been known in Indian ornithological literature under the specific name *melanocephalus*, which is Greek for "black-headed," a name applied by Linnaeus in 1766, presumably to the male bird. The female, however, was described by Linnaeus in 1758 under the name *Sturnus luteolus* and, by the Law of Priority in nomenclature, the name *luteolus* takes precedence as the correct name for this bird.

This Oriole is protected throughout the year in Bombay, the United Provinces, Bihar and Orissa, Bengal, Assam, Burma, Madras, and Mysore.

CAMBODIA COTTON (*GOSSYPIUM HIRSUTUM*).

ITS DETERIORATION AND IMPROVEMENT. *

BY

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CAMBODIA cotton is an Upland American variety of cotton. It was first brought to the notice of cultivators in the Madras Presidency in 1907, when a small quantity of unselected seed was distributed. From the beginning its cultivation spread rapidly until, when the Indian Cotton Committee made their report in 1919, the area under this crop in this presidency alone was estimated at 200,000 acres.

During the first few years, the reports received from buyers regarding the quality of the lint were very favourable. Later, however, after the cotton had been in the hands of the cultivator for about ten years, and had been exposed to the full effect of climate and careless methods of cultivation, less favourable reports began to come in. It was definitely asserted that the lint was shorter, weaker and much more stained than was the case at first. The plant was stated to have deteriorated.

The charges made were true enough, but to say that the crop had deteriorated was merely to express a fact in a conveniently short manner without correctly realizing what causes were involved.

CAUSES OF DETERIORATION.

A similar reaction on the part of the crop, differing only in type, would have given a result which, with equal looseness of

* Paper read at a Conference held under the auspices of the Madras Agricultural Students' Union, Coimbatore, December 1920.

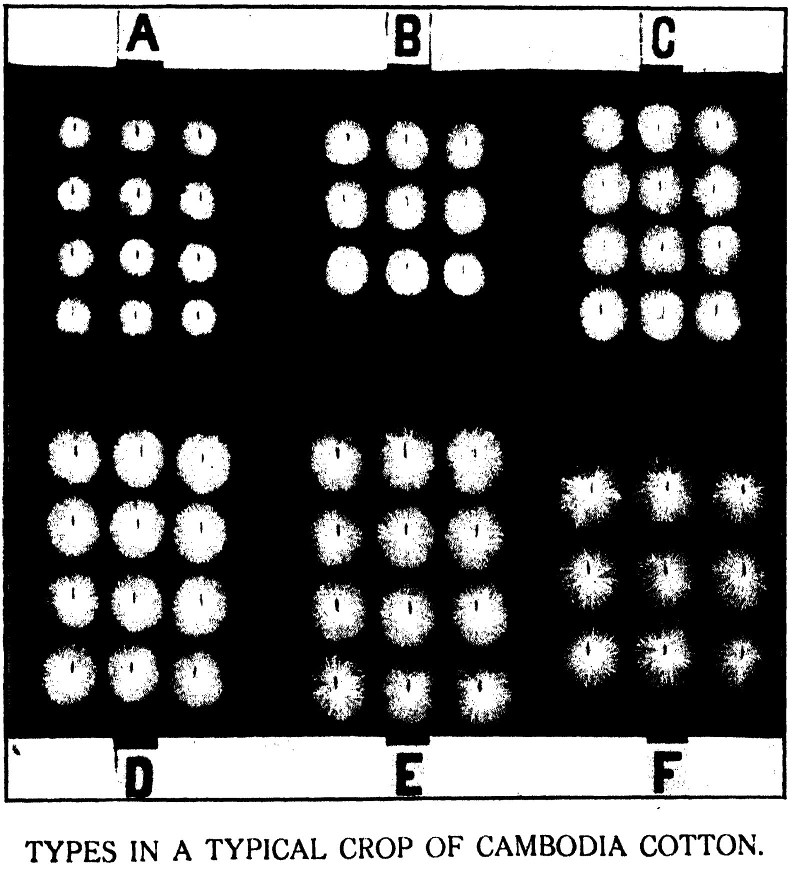
expression, would have been termed acclimatization. We may estimate correctly the causes of the change which occurred by considering the charges made under two heads.

First. Weakness and staining. There was only one factor at work here, namely, the bollworm. When first grown in this presidency, Cambodia cotton was no more able to withstand the attack of the bollworm than it is at the present time. In this respect it has neither deteriorated nor improved. What really happened then was that the cultivator unwittingly set to work vigorously to breed bollworms. Desire to reap a large profit from the crop led him to adopt the practice of leaving it standing for several years in succession. Thereby he over-reached himself. For, by so doing, he ensured a steady supply of food all through the year for the bollworm population. The natural result was that the bollworm increased rapidly in numbers, and in consequence the number of bolls attacked also increased. Thus a larger proportion of the 1918 crop was stained and weak than was the case with the crop of 1908. If the bollworm can be reduced in numbers, then the loss in yield and deterioration due to this cause can be reduced.

Second. Shortness of staple. Here there is an entirely different question to be dealt with. The first seed distributed was unselected and was a mixture of types. Plate XV shows some of the types to be found in the Cambodia cotton crop at the present day. All the possible types are not represented. There are others intermediate between the shortest and the longest. Probably not all of these types were present in the original mixture and not all would breed true if isolated and sown separately. The others have arisen by cross-fertilization within the Cambodia population and possibly latterly by contamination with Dharwar-American cotton.

Now when a mixture of types is given out for cultivation the plant population so raised does not remain stable. New types arise by cross-fertilization, and all the types do not react to their environment in exactly the same way. If the bulk of the seed first issued was from the types D, E, F, as it probably was, and if the

PLATE XV.



TYPES IN A TYPICAL CROP OF CAMBODIA COTTON.

conditions of their environment had been such that they favoured these types, they would have continued to form the major proportion of the population. Cambodia cotton would not then have deteriorated in respect of length of lint, but would have remained very much the same all through. It would in fact have become acclimatized.

Conditions, however, in this country, when allowed full sway, are not generally favourable to the growth of the best qualities of exotic cottons. The poorer, medium quality, early, more vigorous types are better suited to the climate and careless methods of cultivation than are the better quality types. When, therefore, the mixture was distributed and then left to itself, the poorer types gradually replaced the better and usurped their position as chief ingredients of the mixture. Thus after a time a larger proportion of the lint obtained from the crop was of poorer quality than was the case at first, with the result that the plant was accused of having deteriorated. Fortunately, the good types are not lost, they have merely receded into the background. They can be brought into prominence again by the artificial aid of selection.

MAIN LINES OF IMPROVEMENT.

There are two main lines along which crop improvement work usually proceeds. The first is the more or less rough and ready method termed plant to plant selection, which in a refined form works as follows :—

First season. A sample of unselected seed as ordinarily used by the cultivator is obtained and sown. In the case of Cambodia cotton the resulting crop would consist of a medley of types giving produce similar to A, B, C, D, etc. In this population a number of plants are selected and numbered. The produce of each of these plants is harvested separately, and only such lots as approach nearest to a certain standard are retained.

Second season. Separate plots are sown with the seed of the selected plants. When the crop is old enough, each plot is examined to determine whether the culture is pure in respect of habit of plant.

If impure, representative plants of each type noted are marked. If pure, a number of the best looking plants are marked. The flowers on these marked plants are selfed. Early in the harvesting season each plot is gone over again and the produce of each plant is examined. The object here is to determine whether in the impure lots there are any plants worth keeping which have been overlooked, and whether the lots pure for habit appear pure as regards type of produce. If any of the latter prove impure, the fact is noted and the selfed plants are examined to see that the different types are all represented. At harvest the produce of each marked plant is gathered separately and put through a further critical examination in the laboratory. As a result of this examination some plants may be discarded. Single plants from impure lots are kept separate as in the beginning, but the selfed seed from the marked plants in such lots as prove to be pure is mixed.

Third season. In this season there will probably be enough selfed seed of the pure type to permit of two sets of plots being sown: one to produce pure seed and the other to test the yielding qualities of the pure cultures against one another and the local mixture. The seed plot is a quarter of an acre or more in area, and is placed as far from other cotton as possible to minimize the risk of cross-fertilization. At harvest the produce of the plants in the centre of the plot is gathered separately and set aside to provide seed for the next season's sowing. The test plots are in the form of long strips from 2 to 4 cents in area, and are sown side by side in series. The series is repeated as many times as the quantity of seed at disposal will permit, *e.g.*, local, 1, 2, 3, 4, local, 1, 2, 3, 4 and so on. The produce of each strip is harvested, weighed and ginned separately, and the results are recorded. This process of growing pure seed in large plots and of testing yield is carried on for 3 or 4 years, so as to eliminate the effect due to variation in season. As it proceeds, if possible some of the types are discarded. The seed plots of those remaining are increased in size until sufficient lint of each is obtained for a spinning test to be carried out. On the results of the spinning and yield tests the final selection of one type for distribution to the cultivator is made.

This method has the disadvantage that it may limit the range of improvement. For whatever the standard set up, types which do not conform to this standard but which may nevertheless possess useful characteristics are liable to be lost. If the type selected for distribution has been judiciously selected and well tested, its cultivation will spread rapidly. And if, as should be the case, a steady stream of pure seed flows from the selecting body to the cultivator, the selected type will soon occupy the whole area on which the crop is grown. Moreover, if the standard set up is a high one, this method affords no definite evidence of the possible existence of the type desired except actual discovery. Failure to find the type aimed at does not prove that it does not exist. At the same time, the ideal might be an impossible one and continued search by the method described might merely result in waste of time.

The second line of procedure is in its first stage similar to that just outlined. It differs from it in that instead of picking out a limited number of likely plants the crop is gone through until all the different types have been secured. Single plant selection and self-fertilization are carried on until all these types have been obtained in pure cultures. From these a few of the best are selected and tested in the field and in the mill. The best of these is then given out for cultivation as before. This constitutes the first stage of improvement.

The next step consists in taking all the types which possess one or more useful characters in the highest degree, and by judicious cross-fertilization endeavouring to produce a type which combines in itself all the useful characters in the highest degree. This is, of course, the most difficult part of the whole scheme. It involves the careful study of the inheritance of all the various characters met with, even though some of them may have no apparent economic significance. This second method, *i.e.*, isolation of types and hybridization, is the one which it is proposed to follow.

So far we have been dealing in general terms; it is now necessary to go into more detail.

The whole aim of the work on Cambodia cotton is to make it possible for the cultivator, following reasonable methods of

cultivation, to obtain per acre the heaviest possible yield of lint of one inch or more in length. Yield per acre can be increased in two ways: by reducing the loss caused by pests and by the production or discovery of a more productive type.

The two main pests from which Cambodia cotton suffers at present are stem-weevil and bollworm. Exactly how much damage these two pests do singly or together is not definitely known. It is certain that together they do a considerable amount of damage, and that the bollworm is more destructive than the stem-weevil. The most hopeful methods of combating these pests are (1) growing a type of plant wholly or partially immune from their attack, and (2) uprooting the whole crop as early as possible each year, and leaving as long an interval as possible before sowing the next crop. There seems some likelihood that the first method will be successful in the case of the stem-weevil, but in the meantime starvation appears to be the best method of dealing with the bollworm. At present the interval between the up-rooting of one crop and the sowing of the next is in general not more than two months.

Now Cambodia cotton yields twice in the year, once in the season, *i.e.*, before the beginning of May, and once in the summer, *i.e.*, from about the middle of June. This second crop is not nearly so good as the first and is very badly infested with bollworm. If therefore a type could be found which would give practically all its yield in the season, and as much then as is now obtained from both summer and season pickings, there would be very little point in keeping the crop standing after the beginning of June. This would permit of a very much longer interval being maintained between successive crops, and would result in the return of the bollworm to its original status, *viz.*, that of a minor pest. So much then for the first method of increasing the yield.

The production of a heavier yielding type is a little more complicated, and involves the study of the following characters among others—the size and shape of the plant which affect the number of plants which can be grown per acre, the number of bolls set, the size and shape of the boll, the number of locks in the boll, the number of fully developed seeds in the lock, the weight per seed,

and the weight of lint per seed. The scope of this paper does not permit of all these characters being considered, and only the two last mentioned will be dealt with, *viz.*, seed weight and weight of lint per seed.

Balls working with Egyptian and Harland with Sea Island cotton found a positive correlation between seed weight and weight of lint per seed. From the table on the next page it will be seen that a similar correlation holds good with Cambodia cotton. It will be seen that as the weight of the seed increases, the weight of lint per seed increases. The lighter seeds give a lower minimum and maximum weight of seed than the heavier, and do not carry really heavy weights of lint. The explanation of this relationship appears to be this. A heavier seed is a bigger seed. It, therefore, has a bigger surface area and can carry more fibres. A seed cannot carry more fibres than its surface area will hold but may carry fewer. A light seed therefore cannot carry a heavy weight of fibre, but a heavy seed may carry anything from a light weight to a heavy weight of fibre. Consideration of this feature brings out an interesting point in regard to ginning percentage. The maximum weight of fibre per seed appears to be about three-fourths of the weight of the seed. The ginning percentage for any given weight of seed with the maximum weight of fibre is therefore practically the same all through, about 43 per cent. A small seed carrying the maximum quantity of fibre possible will, therefore, give a higher ginning percentage than a heavier seed carrying less than its maximum, although the actual weight of fibre carried by the heavy seed is more than that carried by the lighter seed. Harland found that in Sea Island cotton there is a positive correlation between weight of fibre per seed and weight of lint per acre. If this holds good with Cambodia cotton, the figure obtained for weight of fibre per seed will be a better indicator of the value of a cotton than ginning percentage, unless ginning percentage is used as an indicator of weight of fibre per seed. Ginning percentage is in fact a very minor consideration compared with yield of lint per acre.

Much more might be said about the other characters mentioned above but time does not permit. It has only to be said in conclusion

Weight of fibre per seed.

Weight per seed.

Mg.	31-35	36-40	41-45	46-50	51-55	56-60	61-65	66-70	71-75	76-80	81-85	86-90	91-95
61—65		1											
66—70	1	1											
71—75		1	2										
76—80		1	3	1	3	1							
81—85	2	1	4	1	3	1							
86—90	1	5	1	6	1		1						
91—95		1	2	5	4	3		1					
96—100		2	2	6	7	8	2						
101—105			2	6	10	9	6	1					
106—110			2	5	10	3	6	3					
111—115			1	2	9	9	6	5	1				
116—120				1	2	10	12	4	2	1			
121—125				1	2	8	11	5	2	1	2		
126—130					2	3	5	2	3	3	1		
131—135							2	2	4	1		1	
136—140					1		6	1	2	2		1	
141—145								1		2			
146—150									2			1	
156—160													1

that the attempt to combine all the useful characters in the highest degree in one plant may fail at some particular point, owing to incompatability between certain characters. If, however, anything like this should occur, we shall have the satisfaction of knowing exactly where we stand and up to what limits improvement is possible.

IMPROVED FIELD FOR AGRICULTURAL INVESTIGATIONS. *

BY

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A REVIEW of the world's progress in agriculture during the last 40 years reveals an immense and ever-increasing amount of scientific work on matters concerning that industry. During that period great strides have been made in soil chemistry and biology. Much light has been thrown on plant physiology and on the functions of that group of substances usually termed plant food. Modern plant-breeding has developed, animal nutrition has been the subject of numerous exhaustive investigations, and great progress has been made in the study of milk products. From the point of view of practical farming, we find that most improvement has been effected during the period in the breeding, feeding and treatment of stock, in dairying and in plant-breeding and in the treatment of pastures, and there is no doubt that along these lines (with the exception of the breeding of live stock) improvement has been the direct outcome of scientific work. The study of soils and plant physiology has, on the other hand, led to little change in actual cultivation practice. In the West tillage remains much where it stood. Before our day crops were grown in rows and inter-cultivated, ploughs and cultivators were

* Presidential Address delivered before the Agricultural Section of the Indian Science Congress, Calcutta, January 1921.

much the same as they are now, and the value of manuring was thoroughly recognized. Stagnation probably arose from the fact that science had little of value to suggest along the lines imposed by existing conditions. Pending some marked improvement in power or implements, sufficient to permit of considerable variations in practice, these restrictions appeared likely to remain. Europe is, however, now on the threshold of very great possibilities through the development of the agricultural motor tractor, through which it will now be possible to plough and subsoil to a greater depth, to cultivate and sow under conditions more nearly approaching the optimum (hitherto impossible in unfavourable seasons), and to time operations so as to ensure the minimum loss of soluble plant food. It may even be possible to vary considerably the cultivation of the lea break, a matter which up till now has presented almost insuperable obstacles. Any one who has experience of agriculture in Europe can thus see immense possibilities owing to this sudden access of power by which a man is able to control 3 or 4 times the amount of power hitherto possible. Whether science will be able materially to assist the Western farmer in making the most of the new conditions remains to be seen, but it requires little imagination to see a useful field for properly organized investigation.

To those who have followed developments in India, it would seem that the introduction of new implements should similarly improve the prospects of a change in agricultural practice. When it is considered that, until a few years ago, practically the only implements to be found on the alluvial tract of Northern India were the plough and the levelling beam, while to-day the more important of Western implements, made lighter and most suitable for draught by Indian cattle, have been introduced with growing success into many parts of the country, it would be a strange thing if all this did not signify, in some way or other, a possibility of greater variation in tillage operations. Although the undoubted success hitherto met with in improving crop production in the country by improved tillage may be said to be due more to a greater efficiency of the existing methods of cultivation than to a change in the methods themselves, still there is no doubt whatever that through improving

farm implements a greater control over the soil has been attained, and, consequently, a greater possibility of approaching more nearly to optimum conditions for crop-growing. For example, the furrow turning plough has given a vastly increased power of turning surface organic matter into the soil. The possession of field cultivators means the possibility of a more thorough soil preparation. Drill cultivators and harrows, the use of both of which amongst growing crops is increasing and giving good results, permit of a greater control of soil moisture and of the concentration of the soluble plant food, particularly nitrates, at depths more suitable to the plant. By the use of rollers and soil compressors a more rapid rise and concentration of soluble plant food at higher levels is made possible. Finally, the advent of the ridging plough means, amongst other things, the possibility of applying smaller quantities of irrigation water per acre and of improving its distribution.

Thus, a combination of implements, likely to give us a much greater control over tillage and irrigation, has been introduced into the country and opens a new field of usefulness for agricultural investigation, new in the sense that there is now a possibility of *applying* some of the more recent work done with regard to soil chemistry and physics, soil bacteriology and plant physiology to practical agriculture. For example, it is obvious that, in order to reap the advantages gained by the introduction of new implements, we should be put in possession of a better knowledge of optimum soil conditions for crops both before planting and during their growth, and should have more information about the movement of soil moisture in various classes of soil under varying conditions. Closely connected with this subject is the question of manures and their application. At present we are hopelessly in the dark with regard to the quantitative side of manuring and to some extent as to the best times of application, although it is certain that manures are used most uneconomically. It is probably largely because of this that the value of soluble artificial manures has not been more generally recognized, and it is significant that the best results have been obtained by the use of comparatively slow acting manures, such as bonemeal and oil-cakes, which are applied in greater quantities than

the more expensive soluble fertilizers. Is this not largely due to the present ignorance regarding time, quantity and location, coupled, possibly, with the difficulties hitherto met with in administering the dose at the proper moment and in the correct place? For a man to attempt to control distribution of a soluble manure, armed with nothing but a plough and a levelling beam, is probably asking too much; but the day for this is over, and it is now possible to apply manure and concentrate it at a much greater range of depth than was possible before.

It will readily be admitted that, in all investigations affecting new operations, a careful check should be kept on the results of these on soil fertility. The worst thing that can be done is to encourage the cultivator to improve his present outturn at the expense of posterity. The question of the maintenance or increase, if possible, of the organic matter in the soil is thus one of very great importance. Although it is quite possible to imagine that the effect of a more intensive cultivation might lead to a depletion of organic matter in the soil, it is equally possible that ways and means will be discovered not only for maintaining this essential constituent at its present level but also for increasing it in the ordinary course of cultivation.

The view expressed that well directed investigation into optimum conditions for the growth of the various crops, coupled with a knowledge of what is actually happening in the soil, will lead to great improvement in agricultural practice, is not mere optimism but the result of a somewhat extensive acquaintance of agriculture in the East and in the West. I should like to point out a few examples, which come to my mind, of work which would be almost certain of a successful issue in India. I have above, for want of a better term, used the expression "optimum conditions" to indicate those conditions which are most suitable for the growth of plants. As an example of the occurrence of such conditions in Nature, we may refer to what are usually called in official statistics "bumper" crops. These crops exceed by large amounts what we call "normal" crops or crops produced under generally favourable but not "optimum" conditions. Their occurrence,

of course, is rare, but occasionally you get good examples. They had such a crop of wheat in certain parts of the Punjab last year. At the Lyallpur Agricultural Station, for example, a wheat crop was harvested which exceeded the normal or fairly good crop by about 50 per cent. The occurrence of such a crop shows, of course, the absence of unfavourable conditions, but, at the same time, suggests a combination of favourable circumstances before and during the growth of crops. The conditions, whatever they were, must obviously have been meteorological combined with a fortuitously favourable timing of the irrigation. Now if we only knew exactly what these favourable conditions were, might we not so control our operations of watering, draining, cultivating and manuring as to make the normal approximate the present bumper ? And the same applies to many other crops. Take cotton for example. The advent of the ridging plough tends to a much better control of irrigation water, and ought to help us to regulate, to some extent at least, the position of the soluble plant food in the soil. Further, one of the chief problems with regard to cotton growing is to prevent the premature shedding of bolls. Under a properly regulated irrigation system this should be quite possible but a way out has not yet been found, owing probably to the non-utilization of our present means of control.

With reference to the possibility of the use of manures in directions hitherto unthought of, I should like to point out an instance witnessed by myself near Dacca of the extraordinary effect of a small dose of bonemeal on a paddy crop. It was in the year 1918 in which, as you probably remember, the monsoon ceased early, and a magnificent looking rice crop throughout Bengal turned out about 30 per cent. short of normal owing to drought. Just outside Dacca amidst a large stretch of the higher lying transplanted paddy land, the crop on which was dried up and prematurely ripened, were to be seen a few fields which had been manured with bonemeal, fresh, unwithered, and properly ripened, giving every appearance of having been irrigated, although no irrigation had been applied, nor, indeed, was such possible. There you had a genuine result, nothing accidental

about it, demonstrating some great principle of immense potential value to the country. The whole thing was very striking and suggestive, and it is hoped will yet lead to results apart from the more immediate conclusion, *viz.*, that, under certain conditions, proper manuring in years of drought may save the crop.

To revert, the improvement in the equipment of the ryot in tillage implements, coupled with a knowledge of how to use these to the best advantage, and with a judicious use of manures—probably in small quantities given at the psychological moment—will render it possible to make a considerable advance on present practices and to increase crop outturns considerably. That the best results, however, will not be obtained empirically will be at once conceded when it is considered that improvement will lie mainly in the correct timing of operations. Moreover, investigations carried out in the usual agricultural fashion, *i.e.*, by plot experiment alone, cannot be expected to give the desired results. The more detailed knowledge that we now require regarding soil conditions can only be revealed by work in the laboratory. The agriculturist is hopelessly handicapped in investigations of this nature unless laboratory assistance is at hand. Again, the optimum conditions for crops will require to be worked out from the botanical standpoint and will also require work of a specialized character. Further, it is necessary that the work should take the form of a more or less concentrated investigation of particular subjects, research work as a rule being not immediately applicable to practice. Success is thus most likely to follow joint investigations in particular directions. What these should be depends on circumstances. A form of concentrated investigation which has already produced results of benefit to planters, and could, doubtless, be vastly improved, may here be mentioned, *viz.*, specialization in crops. Different crops or, at any rate, different groups of crops require different soil conditions, different timings, etc., and a thorough investigation of optimum conditions for each crop or group of crops, combined with a local knowledge of the behaviour of the soil under varying meteorological conditions, would enable the agriculturist to work out a rational system of agriculture

based on a full knowledge of what his crops require and how far these requirements were being met.

At any rate it must be conceded that in addition to an adequate provision for research, which must be uncontrolled and unfettered, a special organization of investigation is called for in order to make the most of the large amount of work which has already been done in India and elsewhere with regard to soils and crops, to fill up the gaps in our knowledge, and to connect up the whole with practical agriculture, and further that such investigations should not be in the form of isolated and unconnected pieces of work but should be concentrated with the object of a more or less immediate application of the results.

AGRICULTURE IN THE SHAN STATES.

WITH SPECIAL REFERENCE TO THE SYSTEM KNOWN AS "TAUNGYA" CULTIVATION.

BY

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GENERAL.

THOUGH this note refers specially to the Shan States, the greater part of it is applicable to the Chin Hills, Kachin Hills, the numerous hill tracts forming part of " Greater " Burma, and also to the hilly districts where " taungya " cultivation is practised.

The Shan States are a group of over 40 Native States lying to the east of Burma proper and between that country and China. The administered area is roughly 57,000 square miles with a population averaging about 22 persons per square mile. The predominant race is Shan, but numerous other races are found in different parts, *e.g.*, Kachins in the north, Palaungs, Lisaws, Was, Taungthus, Inthas, Akhas, Karens and others. Burmans and Chinese are also found more or less scattered throughout.

The configuration of the country is that of a huge irregular plateau intersected by many hill-masses which rise above it. In places it is comparatively flat, consisting of large, grassy, upland plains or sloping downs, well wooded and well watered. In other places of considerable altitude, open rolling downs, almost treeless and comparatively dry, are the main feature. The mean altitude is somewhere about 3,000 feet, but mountain ranges run up 7,500 feet and peaks rise as high as 9,000 feet. The country is well watered,

the main drainage system being the Salween and her affluents and several important tributaries of the Irrawaddy—the Nam-Mao (Shweli), the Nam-Tu (Myitnge), the Zawgyi and the Panlaung. The mountain ranges and valleys have a general north and south trend which is also followed by the rivers and main streams. This irregular series of hill ranges, valleys and streams running north and south, is the characteristic feature of the Shan country as a whole.

Though portions of the Shan States are unhealthy, on the whole the climate is temperate and salubrious. In the deeper valleys the atmosphere is laden with moisture, and during the hot months it is humid and sometimes unpleasant. On the uplands the range of temperature is often wide. During the hot months it may be high during the day, but it drops very considerably at night. During the cold season, dense wet mists hang over the hill tops and roll down the valleys, and they are often not dispelled for some hours after sunrise. In the higher regions from December to February frost is common—as much as 10 degrees of frost have been recorded—and even in the lowest valleys the thermometer has been known to fall to freezing point. Nevertheless, the temperature is on the whole fairly equable and pleasant. The mean temperature at Taunggyi is about 66 degrees, and in one of the hottest valleys the average maximum and minimum were about 96 degrees and 65 degrees, respectively, in April.

The rainfall varies considerably but is generally sufficient throughout for good production. The average annual rainfall is probably about 60 inches and generally speaking it lessens towards the east of the States, though in the Myelat country on the borders of Burma it is only about 38 inches—most probably on account of the protection afforded to it by the lofty range of hills on its western and south-western boundaries. The mountain ranges and hillsides are storm-swept whilst the valleys are often steamy.

Soils

For our purpose we may regard the soil as being derived entirely from the limestone rock which underlies it. By far the greater

portion consists of a sedentary red loam which occupies all the uplands and hillsides, but which gradually merges into finer brown loams on the lower and nearly flat lands and in the valleys ; whilst these again become still finer clay soils in the lowest parts of the valleys. The red upland loams, though derived from the limestone, are almost devoid of lime which has leached out from continual washing by torrential rains. They also appear to be greatly lacking in organic matter and in readily available plant food. They bake very hard on drying, but they are physically fertile, not difficult to cultivate when moist, and when worked the loose soil is readily washed away down the hillsides. The loams and clay soils of the valleys have been thus transported and formed from the washings of the hills. These valley soils have accumulated more or less vegetable matter to which they owe their darker colour and greater fertility. In the lowest parts of the valleys and on the borders of swamps and lakes, these accumulations have produced dark brown or black peaty soils highly fertile when drained.

Though the brown loamy and clay soils cover a comparatively small area, they are of great importance and the former are particularly fertile under proper treatment. In the ordinary course of development of the country, one might expect these soils to come first under cultivation and such has probably been the case ; but there are now wide stretches of land, a great deal of which shows unmistakable signs of former cultivation, abandoned to "kaing" grass or scrub jungle. The lower-lying clay soils and the peaty lands, where sufficient water can be obtained, still form the principal paddy lands and are in most places irrigated, but the rich brown loams have not generally come under dry crops, as might have been expected, in preference to the less rich red soils. They are not generally considered suitable for dry crops. The reason may probably be found in many places in the need of drainage—an operation which the local agriculturist does not understand and which he would probably not practise if he did. He would prefer to go a little higher up the hill where the necessity does not exist. Most of these soils are also sour, and with poor tillage, without drainage or lime, they will give poorer

outturns of wheat, potatoes, etc., than the red soil. The cultivators' explanation of the neglect of these lands is generally that the soil after many years has ceased to give profitable outturns of paddy and has consequently been abandoned. A more probable explanation is that paddy or rice cannot be profitably exported, and the local demand for swamp paddy is satisfied from the more readily watered lower lands. As these latter have gradually come under cultivation encroaching upon the swamps the somewhat higher lands have dropped out. The population is sparse but increasing and the demand for rice for local consumption is rising, and no doubt more land will again go under this crop to keep pace with the growing population; but as roads increase and facilities for export improve, the introduced dry crops—wheat and potatoes, and probably also cotton and beans—will generally be found more profitable than paddy and should spread over all but the lowest of these lands.

The existence of numerous springs and waterlogged areas has given rise to bogs in many places. These bog or "muck" soils are comparatively small in extent and consequently of no very great importance; but where they are firm and deep enough they will often grow good crops of paddy, and if well drained they will produce heavy crops of potatoes, vegetables and other market garden produce. They are not usually difficult to drain, and within easy reach of a good market they are excellent soils for "truck" farming. Except near European habitations where there is a demand for vegetables, these soils have, however, been generally avoided on account of the labour required to bring them into condition.

METHODS OF AGRICULTURE.

The most extensive system of agriculture is that of "taungya" cultivation described below. There is no means of calculating the area annually affected but it is enormous, and in comparison other systems are of small importance. Yet a large part of the population derives its principal food grain, rice, from the swamp paddy which is cultivated in the ordinary way.

The valley bottoms and most low-lying places are devoted to paddy cultivation, and many hillsides and gullies where the

rainfall is sufficient are terraced for the same purpose. Irrigation is a common practice but the few regularly constructed canals are small. Advantage is taken of almost every little stream in the country. Temporary weirs of bamboos, matting sticks and earth, are constructed to turn the water into small distribution channels, and waterwheels and other ingenious methods of raising the water on to higher fields are employed. Waterwheels are also made use of to drive rice and wheat mills, and ingeniously constructed rice "pounders" are automatically worked by water-power. There is nothing peculiar about the method employed in paddy cultivation, the seedlings being transplanted into the fields in the ordinary way; but in some parts where water is not early obtainable for wet nurseries the seedlings are grown as a dry crop on a specially prepared bit of "taungya" land.

The paddy fields are planted year after year with the same crop. There is no attempt at rotation, and manuring is only carried out in fields near the villages. The means of transport do not permit of rice or paddy being profitably exported—the produce fulfils the local demand and the area is largely determined thereby. As many of the lower swamps (such as the edge of the Inle lake which is being encroached upon by silt deposits and weed growth) have gradually become cultivable, they have been turned into paddy fields to the exclusion of higher lands where water is less easily obtainable. But as the demand for paddy is now increasing and the market rates have risen considerably, cultivation is again extending to these less favourably situated fields.

Garden crops are cultivated in the home plots and here cattle manure and ashes are freely made use of. Onions, garlic, chillies, maize, brinjals, many kinds of beans and a variety of vegetables are produced with a minimum of labour. Little trouble is expended on weeding and the plots are usually poorly tilled. Tobacco is universally grown and some of the varieties have a wide reputation for quality. Cotton, sesamum and groundnuts are chiefly products of the "taungya," following paddy.

A good selection of fruits is cultivated in the home plots: pine-apples (of a particularly fine variety), plantains, custard-apples,

guavas, peaches, plums and *Citrus* fruits are all grown. Oranges flourish and are cultivated in groves along the banks of some of the rivers. The orange plantations on the banks of the Nam-Tu are noted for the excellence of their fruits. Plantains and mangoes are poor in comparison with the Burma products.

Tea cultivation is the chief occupation of the Palaungs in Tawng-peng State and also in parts of Hsipaw and elsewhere. The methods employed are haphazard and could no doubt be improved upon. The leaf is mostly sent down to Burma as "pickled" tea (*i.e.*, compressed and fermented in a green state) and not dried as is done for European consumption. Tea plantations are calculated to cover some 12 to 15 square miles of land.

"Taungya" cultivation.

The "taungya" system of agriculture as practised here, besides being of primary importance, is of special interest; and, as a great deal of light has been thrown upon it within recent years, chiefly by investigators in England, the method, though familiar to most people living in the country, will be briefly described.

There are, of course, some slight variations in "taungya" cultivation as practised throughout the vast hill tracts of Burma and the Shan States; but these variations, such as differences in time and method of burning, number and kind of successive crops planted and methods of tillage, are the result of local conditions and custom. In essentials the practice is the same throughout and is very similar to the processes known as "chena" in Ceylon, "ladang" in Malay, "jhuming" in India, and "bushburning" in the West Indies. The process of "rab" in the rice fields of Western India is somewhat different, but probably has a similar explanation, in part at least.

The ordinary system of "taungya" is to cut down the jungle growing on a piece of hillside land which has generally been indicated to the cultivator by the "nats," properly propitiated with sacrifices. If there are any trees the branches are lopped off, and the brushwood with some of the smaller growth is heaped around the stumps and the whole is fired. This operation takes place during the dry weather—February to May—and these jungle fires, as viewed from the plains

on almost any night of the hot weather, are an attractive sight. In some parts, *e.g.*, the Kachin Hills, fire belts are cleared around the "taungya" area to protect the surrounding jungle, but in other places this precaution is not taken. The soil is strongly heated, becomes brick-coloured, and a coating of wood ashes is left on the surface. Sometimes, where the growth is not thick enough, brushwood is carried or carted to the fields, but this is a laborious process and is generally avoided by the selection of well-covered land. Subsequent cultivation depends upon the slope of the ground; only on flat or moderately sloping land can the local plough be used. The ordinary steep-hillside "taungya" is cultivated with the "pauktu," a large hoe, with which the soil is loosened and the seed dibbled in.

A variety of crops is grown—the chief ones being "taungya" or hill paddy, maize, potatoes, sesamum, ginger, groundnuts, sweet-potatoes, gourds, opium, cotton and several kinds of beans. In the widely separated hill tracts of this country, the crops grown differ very considerably as might be expected. Some variety of coarse "taungya" paddy is generally the principal crop, and there are not usually more than two others of great importance in any area.

The land is cultivated from one to three years (rarely four) and then allowed to lie fallow for a considerable period, which may vary, according to circumstances, from 4 years to 15 or 20 or more. There seems to be no guide to the number of tillage or the number of fallow years and, except that in some places a grain crop is usually the first to be sown after burning, no suggestion of any rotation has been revealed by long observation and enquiries.

In parts of the Shan States where there is little fuel to be had, and particularly in the Myelat (described above) and those parts of the South Hsenwi State where the country has been practically depleted of fuel for many miles, little remains but a scanty covering of grass, and the method employed is somewhat different. The custom here is to loosen the surface soil to a depth of about 3 inches generally by means of a single buffalo plough as the land is fairly level. Then, as the soil is at that time hard baked, to break the lumps and to complete the process of loosening requires the use of the "paukpya" (big hoe). The fields are laboriously hoed over by hand,

and after this the dry, loose soil is scraped up into small mounds about 4 feet from centre to centre and about 15 inches high. A pit is then made in the centre of each mound, and a small quantity of cattle manure, dead grass or other dry material collected with much trouble, is set on fire, partly covered with soil and made to smoulder in the pit. The endeavour is not to permit any part to become over-heated but to heat as much soil as possible to a moderate temperature. As, however, the quantity of manure, etc., available for each mound is usually a mere handful, only a portion of the soil is subjected to the action of heat, and the temperature reached must vary very considerably from the centre towards the outside of the mound, where a considerable quantity of soil remains unaffected.

After burning the heaps are allowed to cool, and if the crop to be grown is potatoes the setts are planted in the mounds—from one to three setts in each. But for other crops the heaps are spread again by hand, and the seed is sown broadcast.

The principal crops grown in the Myelat are paddy and potatoes with an occasional crop of sesamum. Potatoes have within recent years become a crop of great value and of importance for export, and wheat, which is a comparatively recent introduction, is now rapidly following suit. The period of cultivation of a "taungya" in the Myelat is two to three years.

AN EXPLANATION OF "TAUNGYA".

The practice of "taungya" cultivation has from time to time been the subject of official investigation for many years—chiefly on account of the enormous amount of damage done to forest areas and the heavy destruction of timber. Administrative departments—the Forest Department and latterly the Agricultural Department—have all given some attention to the problem. In 1912 the Agricultural Department started experiments on a small scale near Pynitha in Mandalay District. Though these had to be abandoned from lack of funds to carry them through, recent results have proved that they were instituted on the right lines.

It was long ago recognized that the people did not practise this system of shifting cultivation from choice but from necessity—that

"the practice of 'taungya' cultivation is not due to any nomadic tendency on the part of the cultivators but to their being compelled of necessity to select new areas." That it is unprofitable to grow crops on ordinary "taungya" land after the second or third year requires very little demonstration—an inspection of standing crops is sufficient proof; but a few measured yields that have been obtained may be quoted :—

(*a*) On a three-year-old "taungya" (at Hsumhsai), sesamum 40 lb. per acre, two kinds of maize nil, beans (*Phaseolus lunatus*) 330 lb. and (*Phaseolus calcaratus*) 370 lb. per acre, castor 100 lb. per acre, and gram 200 lb. per acre;

(*b*) On a field at Yawnghwe farm, wheat 180 to 310 lb. per acre, groundnuts 220 lb. per acre, sesamum and peyin failed.

The necessity for abandonment of the "taungya" is due to the fact that the soil becomes unproductive after two or three crops have been removed; but it has also been ascribed to the excessive growth of weeds with which the cultivator is unable to cope and to surface erosion of the loosened soil. Whilst these last two very probably influence the cultivator to some extent in the direction of abandoning his cleared land, the main reason for his seeking new areas undoubtedly is the first.

The effects of heat upon soils.[1]

In order to show how such an extraordinarily rapid deterioration in productiveness takes place in these soils, it is necessary to enter into a little explanation of the effects of heating; and for

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[1] For this explanation of the effects of heat on soils the writer is indebted to the records of research work given below and to which those who desire more detailed information on the subject should refer :—

(1) Russell and Hutchinson. "The effect of partial sterilization of soil on the production of plant food." *Jour. of Agri. Sci.*, Vol. III, pp. 111–144, and Vol. V, pp. 152–221.

(2) Pickering. "Changes in heated soils" and "Plant growth in heated soils." *Jour. of Agri. Sci.*, Vol. III, pp. 258–284.

(3) Russell and Goulding. "Sewage Sickness." *Jour. of Agri. Sci.*, Vol. V, pp. 27–47.

(4) Russell and Petherbridge. "Sickness in glasshouse soils." *Jour. of Agri. Sci.*, Vol. V, pp. 86–111.

(5) Russell and Petherbridge. "The growth of plants in partially sterilized soils." *Jour. of Agri. Sci.*, Vol. V, pp. 248–287.

the sake of those not well acquainted with agricultural science, it would be well first to explain one or two elementary points.

When a soil has been heated, it produces considerably higher yields than one which has not been so heated. This holds good for all non-leguminous crops. Darbishire and Russell (*Journal of Agricultural Science*, Vol. III, p. 305) showed that soils heated to 95° C. in the laboratory produced two, three or even four times as much crop as a portion of the same soil which had not been so heated, and they conclude that the treatment had in some way brought about a considerable increase in the available plant food. One has only to compare the crop growing on a well-burnt part of a "taungya" with that growing on any unburnt portion to be convinced of the accuracy of this statement; but because the unburnt soil very frequently fails to produce any crop at all, the difference in the case of "taungya" cultivation is often much greater than four to one. The reason for this is not difficult to comprehend when it is borne in mind that these investigators were dealing with fertile soils—probably much richer in organic matter, lime and available plant food than our "taungya" soil. The former soil would at least produce a crop by ordinary methods of cultivation, whilst the latter, though physically fit, will seldom yield a crop worth the name by ordinary tillage alone.

Non-leguminous plants derive their supplies of nitrogenous food from the soil, and the production of ammonia in the soil is mainly the work of micro-organisms which occur in enormous numbers (from a few thousands to over 100 millions per gram of soil according to the character and condition of the latter). The organisms chiefly of interest here are those bacteria which produce ammonia by the decomposition of soil substances and the "nitrifying" organisms which convert that ammonia into nitrates, in which form plants as a general rule absorb their supplies of nitrogen. These organisms are present in all soils, and they multiply with marvellous rapidity when under favourable conditions. The rate of production of nitrogenous plant food is dependent upon the bacterial numbers present in the soil.

But Russell and Hutchinson (*loc. cit.*) have shown that bacteria are not the only micro-organisms which inhabit the soil, but that

there is another group of such organisms which are detrimental to bacteria and which considerably limit the numbers of the latter. This second group is believed to be the protozoa—low forms of animal life with microscopic, jelly-like, unicellular bodies. Three main families of these protozoa have been identified, *viz.*, flagellates, ciliates and amœbæ, and it has been shown, by Buddin[1] and Cunningham[2] as well as by the investigators named above, that when these are present the numbers of bacteria and consequently the production of ammonia are seriously restricted. The organisms, both bacteria and protozoa, occur principally in the surface layers of soil—say, in the uppermost six inches.

These protozoa are larger than the bacteria, but fortunately they have not only lower powers of resistance to heat and to antiseptics but their rate of multiplication is slower. They are more readily killed by heat than bacteria are, and they multiply less rapidly—phenomena only recently discovered but of which the "taungya" cultivator appears to have taken advantage for hundreds of years.

The effects of heat upon a soil in the direction of increasing the plant food may be regarded as twofold. The immediate effect is to render soluble by chemical decomposition some of the nitrogenous substances found in the soil. Ammonia is produced, and the higher the temperature the greater may be the amount expected; but if the temperature reached is high, much organic matter is decomposed and loss occurs. The nitrogenous plant food produced in this way, directly by heat, is available for the use of plants but it very rapidly disappears, and the influence on plant growth on this account is of short duration. But another more durable though still a temporary effect is to be found in the action of heat as a sterilizing agent.

When a soil is heated to moderate or to high temperatures, large numbers of the micro-organisms are destroyed. The protozoa, being less resistant to heat than the bacteria, are killed first. The nitrifying bacteria are also fairly easily killed and generally perish at

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[1] *Jour. of Agri. Sci.*, Vol. VI, pp. 417–451.
[2] *Jour. of Agri. Sci.*, Vol. VII, pp. 49–74.

moderate temperatures, but the organisms which decompose soil substances to produce ammonia are more resistant. Besides which, bacteria produce spores which strongly resist heat and afterwards, on the addition of moisture, will germinate and multiply very rapidly in the absence of their enemies, the protozoa.

Thus it happens that when a soil is partially sterilized by heat the detrimental organisms are killed, and though most of the bacteria may also be killed, there are sufficient left to multiply when conditions of moisture and temperature again become favourable. With their enemies removed they do this at such a tremendous rate that within a few days they have reached the original numbers, and within 3 or 4 months they will have increased to several times the original numbers. Russell and Hutchinson, in their investigations referred to above, have quoted cases of 60 to 120 millions of bacteria per gram of soil in three to four months after sterilization.

Generally speaking, the higher the temperature reached the greater will be the destruction of bacteria and the slower the recovery of the numbers until at about 120° C. all are killed ; but in order to destroy all the protozoa it is not necessary to raise the temperature above 55° or 60° C. At that temperature the number of bacteria is moderately reduced and the recovery is rapid. In fact the maximum bacterial numbers are afterwards obtained when soils are heated to about that temperature. This seems to throw a glimmer of light on the cultivators' preference for smouldering fires and moderate heat. Even at the low temperature of 40° C. maintained for some time, the detrimental organisms suffer very considerably ; and thorough drying, such as most of the soils in this country are annually subjected to, temporarily suppresses their action.

The destruction of the nitrifying organisms, along with the protozoa, is not such a serious matter as might be supposed. It does not "seriously interfere with the growth of plants—as a matter of fact it seems to have but little effect ; plants readily take up the decomposition products, ammonia, etc. Nitrification is shown to be economical but not essential. The excess of nitrogenous plant food in the partially sterilized soil soon becomes so great that it causes

a correspondingly vigorous plant growth."[1] Moreover, as in "taungya" burning, only a portion of the soil is heated high enough to destroy all the organisms; these latter are re-introduced when outside soil is mixed with the other. They immediately begin to multiply at a much greater pace than their enemies which are re-introduced at the same time.

Now the result of introducing untreated soil into partially sterilized soil is to still further increase for a time the bacterial numbers and consequently the production of ammonia and nitrate. This is easy to understand when the relative rates of multiplication are borne in mind. The rise in numbers of bacteria is sustained for a considerable time; but after a while the detrimental organisms which have also been recovering their numbers, though at a less rapid rate, begin to make their influence felt, and there is a depression in the bacterial numbers until the original equilibrium between the two groups of organisms becomes established. When this takes place, the soil will have returned to its original state in respect to plant food being produced by bacteria.

To reiterate, the effect of heating is an initial and considerable increase in the quantity of ammonia present in the soil. This direct effect disappears before long, but it is followed by a rise in the rate of production of ammonia by bacteria and consequently in productiveness of the soil. The latter, or indirect effect of the heating due to partial sterilization, may be sustained for a considerable time. It does not begin until the dry soil becomes moistened by rain, because bacterial (or protozoan) multiplication or activity cannot proceed without moisture, and it is checked or even stopped entirely when the soil becomes dry again.

A "taungya" burnt during the dry months (March to May) is planted or sown on the first appearance of rain. The young crop at first makes use of the ammonia directly produced by the heat and later of that produced by the increasing bacteria. This continues till the crop is harvested, after which the production of ammonia is lessened by the accumulation of that substance (which checks the

[1] *Jour. of Agri. Sci.*, Vol. III, pp. 111—144.

activities of the bacteria) in the soil, and later by the drying of the soil which will eventually arrest the process and check the multiplication of both classes of micro-organisms for the period of the dry season. At the break of the second rains the soil bacteria still retain the upper hand, but before the season's crop has been harvested the detrimental organisms are rapidly gaining in ascendency, and by the time the dry season again comes round they have greatly increased at the expense of the bacteria. It may possibly require a third season for the original relations between the bacteria and the protozoa to be reached, and the effect of the heating may still be seen in a third or even a subsequent crop; but once the original state of equilibrium is fully established between the two classes of organisms, the effect of the burning will have disappeared and the soil will have returned to its previous natural state—which, on account of its poverty in lime and organic matter, is one of unprofitable crop production over very large areas.

It is a significant fact that "taungya" cultivators generally prefer grain crops, particularly benefited by nitrogenous fertilizers, in the first years of their "taungya", and reserve their other crops such as sesamum, groundnuts, ginger, etc., for the later years.

The above outlined explanation of the reasons for "taungya" appears to be the only rational one in the light of recent researches, but soil biologists, bacteriologists and chemists will be needed to carry out very many investigations on the spot before such an explanation can be fully accepted as other than a theory which, as we shall show, the results of practical field experiments strongly support.

The cultivator often attributes the success of his "taungya" crop to the destruction by fire of insects and fungi, and his failure after two or three years to the return of these pests. As he can often support his belief by pointing to the attacks of such pests on unburnt land and after unburnt manure, there is no doubt some foundation for his ideas, but the principal effect of burning is not in this direction.

(To be concluded.)

HISTORICAL NOTE ON EXPERIMENTS WITH JUTE IN BENGAL.*

BY

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INTRODUCTION.

THE following note was written with the object of placing on record a short chronological account of investigations into jute.

At the present time, however, the results of the comparative trials, which are detailed herein, are of particular value as demonstrating to jute-growers that, by using departmental seed, it is possible to seriously increase the yield per acre, and thus, if necessary, grow their requirements on a smaller area. In this case more room is left for other crops.

It is also important to observe that, over a wide tract, dealers in jute have offered, and paid, higher prices for fibre grown from departmental seed than for local fibre. Quality in jute largely consists of length, strength and colour; also the proportion of the length which is free from adherent bark, so often seen at the butt end of the strand, and known in the trade as "root." The longer the strand of fibre the less the proportion of "root" is likely to be, and the greater therefore the value of the fibre per maund. The great height to which departmental jute grows enables it to yield, on the average, a longer strand, a less proportion of root, and therefore a

* This Note was prepared for the Jute Committee of the Bengal Board of Agriculture in December 1920. The introductory paragraph has been added subsequently in view of the discussion going on as to whether cultivators should, or should not, temporarily reduce the area devoted to jute.

more valuable fibre than ordinary jute. It is thus an appreciably more profitable crop for the cultivator to grow than ordinary jute.

Much has been heard recently about the low price of jute fibre and the unprofitableness of the cultivation of jute as a crop. It is perfectly true that poor quality jute is being sold* on the Calcutta market at prices as low as Rs. 3 per maund, which certainly means considerable loss for the producer, but it is also equally true that good jute is being disposed of at anything from Rs. 20 to Rs. 25 per maund. The latter prices are almost unprecedentedly high and mean very large profits indeed to the cultivator who is fortunate enough to obtain them. Moreover, the margin between the top and bottom prices is also unprecedentedly wide. What does this mean ? Merely that there is a dearth of good jute, and a plethora of bad fibre. The last year was a particularly bad season for the growth of the jute crop, a not inconsiderable proportion of which was never capable of yielding long jute worth Rs. 20 per maund. On the other hand, there is no doubt that, if it was not possible to produce fibre worth, say, Rs. 20 per maund, it was in most cases easily possible, by careful work, to bring out fibre worth from Rs. 10 to Rs. 12 per maund, and if these prices can be realized it is not to be disputed that handsome profits are still to be obtained from the cultivation of jute. It is necessary to point out, though, that *good prices cannot be realized for jute to-day unless the fibre is carefully prepared.* This may mean growing a less area ; but even so the profits from well-cleaned fibre will be greater. For instance, suppose one man grows 6 bighas of jute which yield him 5 maunds a bigha, *i.e.*, 30 maunds of fibre in all ; but he has no time to devote careful attention to the preparation of the fibre. He therefore only gets Rs. 7 per maund for his fibre, *i.e.*, a total of Rs. 210. On the other hand, a second person has only 4 bighas of jute, which is a sufficiently small area to enable him to carefully extract the fibre. If he reaps 5 maunds per bigha his total fibre will only weigh 20 maunds ; but as he may easily get Rs. 15 per maund for it his gross revenue may be Rs. 300 from

* December 1920.

4 bighas, whereas his neighbour only obtained Rs. 210 from 6 bighas. There has never been such a wide margin between the prices of good and bad fibre, and it will be obvious from the above data that the right policy for the jute cultivator, at the present moment certainly, if not on all occasions, is firstly to use departmental seed if possible and secondly to make sure of producing fibre of good quality.

General.

About 20 years ago, in 1900, the Bengal Chamber of Commerce approached the Government of Bengal and asked for an investigation into jute, the fibre of which was believed to be deteriorating. A sub-committee of the Board of Scientific Advice was appointed as a result of their representations, and it reported against the idea of deterioration, but attributed the comparative inferiority of fibre then coming into the market largely to the custom, practised by small dealers, of adulterating it with water. At the same time, the committee recommended an investigation, by modern scientific methods, into the possibility of improving the fibre of jute, as regards both quality and yield, and during its existence the committee had made a fairly comprehensive collection of the races of jute with a view to commencing such an investigation. Partly as a result of the recommendations of the committee, and partly on account of representations from the jute trade in favour of legislation against fraudulent watering, the writer was appointed as Fibre Expert in 1904. His first work was in connection with the projected legislation which was afterwards dropped. Later, in collaboration with Mr. I. H. Burkill, who had been a member of the sub-committee of the Board of Scientific Advice, an elaborate series of investigations was commenced, having for their object the improvement of the jute crop. The collection of races of jute made by the sub-committee was available, but it was very much enlarged by a careful survey of the whole of the jute-growing area. All the races of both *Corchorus capsularis* and *Corchorus olitorius* were classified in regard to their cultural characteristics of colour, earliness or lateness, tallness or shortness, and also in regard to the microscopic and chemical properties of their respective fibres. In

this way was commenced the culture of "pure lines," *i.e.*, the progeny of single plants.

CORCHORUS CAPSULARIS.

It was then ascertained by cross-fertilization experiments that the danger of contamination of pure strains by chance fertilization is small. This having been established, the investigation was continued at first with *Corchorus capsularis*, and in the interval some thousands of types have come under observation. The best of these types have been collected and their seed multiplied to such an extent that the progeny of a single plant, *Kakya Bombai*, is now cultivated over about 200,000 acres in Bengal, Assam and Bihar. *Kakya Bombai* was the first of the pure strains to be produced and distributed in quantity : it was first necessary to test it on the spot against local races and the department was greatly helped in this work by the jute trade itself, particularly by Messrs. Sinclair, Murray & Co., and Messrs. Landale and Clark, of Calcutta, and their local representatives, notably Mr. John Luke of Naraingunj. These companies not only put land at their mofussil agencies at the disposal of the department for the test, but went so far as to finance the tests and also to provide supervision. All the department had to do was to offer its advice when required. As a result of these tests, carried out at about 25 agencies scattered all over the jute-growing tract, it was established that, on the average, the yielding capacity of *Kakya Bombai* is superior to local races by about one maund (80 lb.) of fibre per bigha ($\frac{3}{10}$ of acre), also that, because it matures later than any other known race, it is correspondingly less likely to flower prematurely in a drought or as a result of damage by hail. The agency tests were inspected by numbers of local cultivators and thus acted as a demonstration, resulting in a considerable demand for *Kakya Bombai* seed, which, for the next season, exceeds 5,000 maunds or 200 tons.

The results of the agency tests are attached hereto as Appendix I (p. 273).

Other new races of Corchorus capsularis. The investigation did not terminate with the arrival of *Kakya Bombai*. Each succeeding

year has seen the examination of hundreds of small plots, respectively sown with the seed of single plants brought from all parts of the jute-growing tracts. The object is, if possible, to improve on the results already obtained, and the production of hybrids has also been resorted to with the same end in view. All such work is of a laborious nature, and to produce a new strain of jute from the beginning to the time when its seed is available in quantity to the cultivator requires six or seven years. So far only two races of *Corchorus capsularis* have emerged whose yielding capacity is comparable with that of *Kakya Bombai*. These are R. 85 and D. 154. The plants of others, such as D. 101 and D. 151, have considerable stature but comparatively small yielding power. Comparative figures representing the respective yielding capacities of these races will be found on p. 276; and those of crops raised from two samples of seed obtained in 1918 by Messrs. M. David & Co., of Naraingunj, from Simulkandi and Fanduk, on p. 274. The latter proved to be a very complex mixture of types, and it will be seen that they yield considerably less fibre than departmental varieties. On this account they have not been grown in the present year, and a sample of their fibre could not therefore be sent to Calcutta. D. 101, however, of which a sample of fibre grown at Naraingunj is available, may be taken as representing them. Single plant selections from the Fanduk and Simulkandi crops were made last year, but they again compared unfavourably with adjacent standards grown from departmental seed.

It should be remembered that all the new races, excepting *Kakya Bombai*, are largely free from a partial bleaching of the leaves, called *chlorosis*, which affects not only *Kakya Bombai* but also a very large proportion of ordinary jute. The incidence of *chlorosis* in the leaf has been correlated with a deficiency in the surface root system which undoubtedly adversely affects the growth of the plant. This is especially the case in very wet weather, when the superiority of *non-chlorotic* races is always more evident.

CORCHORUS OLITORIUS.

The above remarks refer to *Corchorus capsularis* or "white jute"; but the same process of selection has been extended to

Corchorus olitorius, known to the trade as *desi, tosha* or *bogi* jute. The result of the latter work has been the production of *Chinsurah Green* which has given extremely satisfactory results in comparative tests (Appendix III, p. 278), and a bale of which (*bogi* "two's" grown in the Dacca District) is included in the consignment of samples.

It may be of interest to note here that repeated attempts have been made to produce a hybrid between *Corchorus capsularis* and *Corchorus olitorius*; but although the cross-fertilized flower has set fruit in which seed have formed, the latter have never been capable of germination. Great interest would naturally attach to a hybrid plant of this kind, but the only conclusion admissible so far is that the two species are too far apart biologically for the hybrid to be fertile.

Seed supply.

The question of seed supply is one of great importance ; there was always a small demand for seed from the department, but before 1915 no selected seed was available, and although a small area of seed jute was usually grown on Government farms, there was naturally no organized system of supply. With the advent of *Kakya Bombai*, however, and especially after the results of the jute agency tests were available, we found ourselves in possession of a race of jute whose yielding capacity had been amply proved. Moreover, a serious demand for the seed seemed to spring up immediately. In 1915 Government agreed to a scheme whereby arrangements were made with indigo planters in Bihar to produce seed. Messrs. Birkmyre Bros. also grow a considerable amount of seed on their Assam estate. At this time the price paid for clean seed germinating 90 per cent. was Rs. 8 per maund plus cost of bags f.o.r. nearest station to producer ; but the demand for the seed has expanded so rapidly that Rs. 12 per maund was paid for last season's crop, and from Rs. 15 to Rs. 20 will be offered in the coming season. Nevertheless the amount of seed produced is, because of competition from crops like sugarcane, not sensibly increasing, and unfavourable weather has reduced the total to about 1,000 maunds this year, instead of an average supply of about 2,000 maunds. On the other

hand, there is a demand for at least 5,000 maunds for the coming crop, and the reputation of the seed is now such that cultivators are willing to pay much higher prices for it than for local seed.

In view of the limited facilities for production it is obvious that, if the seed is sold in the ordinary way, it would not be possible to seriously affect the quantity of jute fibre produced within a reasonable time. Mr. Milligan, therefore, after consultation with panchayets in the Dacca and Mymensingh Districts, decided to try a scheme which amounts in effect to making the ryot himself do the last multiplication of the seed. To this end, through the panchayets, cultivators were presented with ¼ lb. of *Kakya Bombai* seed, on condition of a promise not to cut the resulting crop until the seed had ripened. In this way each cultivator obtained enough seed to sow 3 bighas of *Kakya Bombai* jute in the next season. It was found by actual enquiry that the cultivators were enthusiastic over the scheme, and that a very large proportion of them had kept their promise and obtained seed for sowing in the next year. The first distribution only involved 100 maunds of seed but this went to 30,000 cultivators. Afterwards much larger quantities were distributed in the same way. This scheme will be persevered with, and, as always, particular attention will be paid to tracts, like Gafargaon, which normally produce a considerable amount of seed for export to Faridpur and low-lying parts of Dacca, Mymensingh and Tippera. In this way it is obvious that, indirectly, the efforts of the Agricultural Department in the production of jute seed can be considerably reinforced. A later development is to place agricultural associations who are producing departmental seed in Gafargaon, for instance, in communication with a similar association in Faridpur, whose members are unable to produce jute seed, and are obliged to buy it every year. This development is only in its inception and it will be necessary to move slowly at first if it is to be successful ; but it has great possibilities. The price to be obtained for departmental jute seed, having doubled in the course of ten years, tends in itself to encourage the local production of seed jute ; but it remains to be seen whether the measures outlined above

will ultimately provide sufficient seed. On the other hand, if a further serious rise in the price of seed were to take place, the raising of jute for seed would become a profitable agricultural operation, especially in Bihar where it is at present overshadowed by sugarcane. In this case private efforts could probably be relied on to produce a large quantity of seed.

It is perhaps worth while to point out that the cost of the seed is a comparatively small item to the cultivator. If he is in the habit of paying annas four per seer for his seed, and sows 6 seers per acre, he lays out Rs. 1-8; if he decides instead to grow departmental jute at annas twelve per seer, and sows $4\frac{1}{2}$ seers per acre, the latter costs Rs. 3-6. If the latter seed produces two maunds more fibre per acre, the cost of production may be an extra Rs. 2-8, making a net difference in expenditure of Rs. 4-6 in all. On the other hand, two maunds of fibre ought to be worth Rs. 16, so that the cultivator is a gainer to the extent of Rs. 11-10 per acre by using departmental seed. This accounts for the popularity of the seed.

APPENDIX I.

Results of tests at mofussil jute agencies in 1916 and 1917 with* Kakya Bombai *against typical local jutes.

Serial No.	Place	Name of Agency	Outturn of fibre of Kakya Bombai per acre		Outturn of fibre of local jute per acre		Difference in favour of Kakya Bombai per acre		REMARKS
			M.	Sr.	M.	Sr.	M.	Sr.	
1	Saidpur ..	Sinclair, Murray & Co. ..	24	30	21	5	3	25	Average of 5 plots of each kind.
2	Durwani ..	Ditto ..	17	35	15	4	2	31	Average of 8 plots of each kind.
3	Mymensingh ..	Ditto ..	22	17	17	36	4	21	Average of 13 plots of each kind.
4	Domar ..	Ditto ..	20	27	16	10	4	17	Average of 3 plots of each kind in 1917 only.
5	Sarisabari ..	Ditto ..	15	29	15	6	0	23	Average of 8 plots of each kind.
6	Sarisabari ..	Landale & Clark ..	20	28	17	31	2	37	....
7	Haldibari ..	Ditto ..	27	0	14	10	12	30	Average of 4 plots of each kind.
8	Naraingunj ..	Sinclair, Murray & Co. ..	21	0	18	9	2	31	Average of 6 plots of each kind.
9	Naraingunj ..	Bird & Co. ..	10	20	9	0	1	20	Bidiaya Sundar and *Kakya Bombai* cut at beginning of July on account of rise of flood. The increased return from *Kakya Bombai* was enhanced by superior quality of its fibre due to early cutting.
10	Naraingunj ..	David & Co ..	19	30	18	20	1	10	Average of 2 plots of each kind in 1917 only.
11	Chatalpara ..	Landale & Clark ..	16	20	13	38	2	22	Average of 5 plots of each kind.
12	Chaumahani ..	Ditto ..	25	5	26	6	..		Average of 4 plots of each kind; on further careful testing at Dacca these figures were reversed, there being a margin of over 3 maunds to the acre.
13	Chandpur ..	Sinclair, Murray & Co. ..	14	3	12	3	2	0	Average of 4 plots of each kind.
14	Nikhly ..	Ditto ..	14	24	13	26	0	38	Average of 8 plots of each kind.
15	Akhura ..	Ditto ..	16	22	14	9	2	13	Average of 5 plots of each kind in 1916 only.
16	Ashuganj ..	Ditto ..	22	6	18	16	3	30	Average of 2 plots of each kind in 1916 only.
17	Serajgunj ..	Ditto ..	23	20	16	20	7	0	Average of 4 plots of each kind in 1916 only.
18	Jalpaiguri ..	Ditto ..	18	30	11	22	7	8	....

Comparison of Kakya Bombai *with local races.*

1919. *Jute variety test on Messrs. R. Sim & Co.'s Chowrapara (Naraingunj) plot.*

Name of variety	Average yield per acre of duplicate plots
	M. Sr.
Dacca Bao	12 7
Simulkandi	7 15
Fanduk	11 10
Kakya Bombai (average of four plots) ..	17 6

1919. *Variety test at Rangpur Cattle Farm.*

Kakya Bombai	19 20
Fanduk	14 20

1919. *Variety test at Rangpur Demonstration Farm.*

Name of variety	Yield per acre
	M. Sr.
Dacca Bao	23 0
Simulkandi	16 33
Hewti (Local Rangpur)	20 0
Kakya Bombai (average of three plots) ..	27 35
R. 85 (Recent Dacca selection)	30 5

1919. *Variety test at West Shoti Field, Dacca Farm.*

Kakya Bombai (average of four plots) ..	17 14
Simulkandi (average of two plots)	13 26
Fanduk (average of two plots)	13 15

The above results obtained at the jute agencies, also at the Rangpur and Dacca farms, would seem to leave no reasonable doubt that *Kakya Bombai* is a better yielder than any local race which has so far been tried against it. The agency tests were of course an excellent opportunity for discovering a heavier yielding race, and the department was fully alive to this possibility. In the few instances when adverse results were experienced, the local seed was brought to Dacca for investigation and tested in the next year on the farm. In each case, however, the departmental selection proved in the end to be better. To sum up, of tests at eighteen agencies, at fifteen of which the experiments were repeated a second year on reversed plots, there was only one case—Chaumahani—where the average figure for the two years was against *Kakya Bombai*. On further investigation at Dacca even this was not upheld.

Similar results have been obtained on Government farms at Dacca and at Rangpur, and it would appear that *Kakya Bombai* may be regarded as a better yielder than the average local race by about a maund of fibre a bigha, or 3 maunds an acre.

APPENDIX II.

Comparison of Kakya Bombai *and other new pure races of jute selected at Dacca.*

Dacca Farm, 1919. In this case R. 85, one of the new races, was used as a standard, and each plot of the other types had a plot of R. 85 on either side of it. This was done to eliminate the effect of uneven soil as far as possible.

Name of race	Average yield of duplicate plots		Average yield of adjacent standard plots of R. 85 per acre		Difference	
	M.	Sr.	M.	Sr.	M.	Sr.
D. 154	19	30	17	29	— 2	1
Kakya Bombai ..	16	5	17	14	+ 1	9
D. 101	20	5	21	5	+ 1	0
D. 136	13	0	17	30	+ 4	30

Rangpur Cattle Farm, 1919.

D. 154	24	12	24	33	+ 0	21
D. 136	22	27	24	3	+ 1	16
Kakya Bombai ..	19	20	21	24	+ 2	4

Dacca Farm, 1920.

Name of race	Average of duplicate plots per acre	
	M.	Sr.
D. 154	18	0
R. 85	18	25
Kakya Bombai	19	20
D. 101	12	5

Godenail, Naraingunj, 1920.

Name of variety	Average yield per acre of duplicate plots
	M. Sr.
D. 154	27* 0
R. 85	22 16
Kakya Bombai	27 20
D. 101	15 15

Rangpur Cattle Farm, 1920.

D. 154	26 6
R. 85	27 13
Kakya Bombai	25 36

Average results over two years.

Taking the average yields of each race at different places over the two years we have the following figures :—

Name of race	Average yield in all experiments over two years, per acre
	M. Sr.
D. 154	23 0
Kakya Bombai	21 30
D. 101	15 35
D. 136	17 33
R. 85	23 0

Thus, as far as we have gone, it would appear that both R. 85 and D. 154 are, on the average, rather better yielders than *Kakya Bombai*. Both D. 154 and R. 85 are non-chlorotic races, and sample bales of their fibres as well as those of *Kakya Bombai* and D. 101 are available for inspection.

* This figure is the average for a number of plots, the soil of some of which varied somewhat. It is therefore not strictly comparable.

Appendix III.

Comparison of the new pure race "Chinsurah Green" with other Dacca selections of Corchorus olitorius.

Godenail, Naraingunj, 1918.

Name of race	Average yield of duplicate plots per acre	
	M.	Sr.
Chinsurah Green	28	33
R. 26	18	36

Rajshahi Farm, 1918.

R. 26	15	30
Chinsurah Green	21	4
R. 27	17	7
R. 30	15	31
R. 62	14	19
R. 29	13	26

Chinsurah Farm, 1918.

Chinsurah Green	21	23
R. 27	14	21
R. 30	20	3
R. 29	18	18
R. 26	18	2

Dacca Farm, 1919.

Name of race	Average yield of plots per acre
	M. Sr.
Chinsurah Green	28 8
R. 26	21 36
R. 30	21 18
R. 62	23 10

Chinsurah Farm, 1919.

Chinsurah Green	29 32
R. 26	28 20
R. 30	25 17
R. 62	25 8

Rajshahi Farm, 1919.

Chinsurah Green	20 8
R. 26	14 16
R. 30	14 9

Average yield of pure races of Corchorus olitorius *on all plots over three years.*

Name of race	Average yield per acre
	M. Sr.
Chinsurah Green	24 38
R. 26	19 24
R. 30	19 17
R. 27	15 34
R. 29	16 2
R. 62	20 39

The " Chinsurah Green " is a green race of *Corchorus olitorius* with a remarkably heavy yielding capacity, which has exhibited itself at all places where it has been tried. In the field it does not, as might be expected, grow very much taller than other kinds, but the plant contains a considerably higher percentage of fibre and its higher yields are largely due to this. A sample bale of its fibre is available for inspection.

THE FOURTH ENTOMOLOGICAL MEETING.

THE Fourth Entomological Meeting was held at Pusa from 7th to 12th February 1921, both days inclusive, and was attended by over forty entomological workers, both professional and amateur, from India and Ceylon, a point about these meetings being that they are not confined to members of the Agricultural Department but have from their inception in 1915 been open to all interested in any branch of Indian Entomology. The delegates to the Fourth Meeting included representatives from the Imperial and Provincial Departments of Agriculture in India, the Indian Forest Service, the Indian Medical Service and Medical Research Association, the Museums Service, the Indian States, the Indian Tea Association, and the Ceylon Department of Agriculture.

The Proceedings were opened with a short introductory speech by Mr. S. Milligan, Agricultural Adviser to the Government of India, after which the Chairman of the Meeting (Mr. T. Bainbrigge Fletcher, Imperial Entomologist) delivered an Address in which he welcomed the various delegates to the Meeting, gave a brief *resumé* of progress since the Third Meeting, and deplored the deaths of four former fellow-workers, *viz.*, Messrs. Howlett, Paiva, Mitter and Lord Walsingham. Referring to the published work recently issued or in progress, he indicated briefly what is being done in the case of the *Fauna* volumes on insects and drew attention to certain cases of misleading titles and dates of publications. Some account was then given of the action taken on the Resolutions passed by the preceding Meeting.

The Chairman then proceeded to deal with the magnitude of the losses to the national wealth of India caused by insects and said :—" We are meeting here as a body of men more or less interested in the study of insects. Some of us are whole-time workers

in this study, to others it is only part of their work, whilst others again find in Entomology a hobby. Some of us are interested in the economic aspect of the subject as applied to agricultural or forest crops or to diseases of man or animals, others derive their main interest from a study of the habits or systematics of insects or other aspects of Entomology, but we are all united in the study of insect life. In the case of those who do not share this interest there is sometimes found a sort of *cui bono?* attitude towards Entomology and its votaries, an idea probably founded on the fact that insects are small animals and that, therefore, forsooth, they are of small importance. We who deal with entomological questions know well that this is not the case but probably few even of us have tried to realize what is the real importance of the study of Entomology in a country such as India, where seven-tenths of the people depend directly for their livelihood on the produce of their fields, which produce is ravaged by insect pests both before and after harvest, and where such a vast aggregate toll is taken by insect-borne diseases both amongst man and his domestic animals. It is usually computed, by those who are in the best position to judge, that the annual damage to agricultural crops by insect pests is about ten per cent.; that is to say, the farmer who reaps what he considers to be a normal full crop actually gets only nine-tenths of what he would have got had there been no damage by insect pests. We have few exact records of damage, but in the case of main crops such as rice it is probable that an estimate of ten per cent. damage is a fair one. Wheat is rather an exception, although it is seriously damaged by termites in some districts, but as against this it is badly damaged in store after harvest. I have been at some trouble to collect figures of the annual average value of the outturn of agricultural crops in India and this comes to the total value of Rs. 16,824,273,000. Applying the ten per cent. rule to this we get an annual loss due to crop-pests of Rs. 1,869,363,666, or say Rs. 1,800,000,000 in round figures. I have taken no account of losses to stored grains, holding these as covered by the ten per cent. rule. Large as this loss is, it is only a part of the damage wrought by insect pests. We have roughly a

quarter of a million square miles of forest in India, of which roughly a half is workable ; I cannot give even a rough guess at the average amount of damage done annually by insect pests in Indian forests but we shall be well within the mark, I think, in placing it at an average of Rs. 100 per annum per square mile over the workable area, neglecting the unworkable areas altogether, and this figure gives us another Rs. 12,500,000 to add to our bill against the insect world. Then we have the various insects which carry disease to man and animals. I believe that somewhere about a million deaths per annum are estimated as due to malaria, without taking into account the incalculable loss to the wage-earning capacity of the people due to this disease. In the twenty years 1898—1918 a total of 10,254,221 people are returned as having died of plague, or an annual average of 512,711. Then we have other diseases such as kala-azar and elephantiasis and a proportion of such diseases as cholera, so that we shall probably not be far wrong in estimating the annual death-roll from insect-borne diseases as approximately 1,600,000. It is difficult to put a money-value on this loss, but it must be remembered that the figures given are totals of all degrees in the population and that not all are wage-earners, so that we may estimate a modest value of Rs. 100 per life, which gives us a figure of Rs. 160,000,000. Next we have the cattle, on which the whole cultivation of the country depends, and the total money-value of these animals may be estimated at Rs. 477,950,000 ; taking the losses in live-stock and animal labour or produce (hides, milk, flesh, eggs, etc.) due to premature death, debility or damage caused by arachnids and insects at 8 per cent. of this total value, we find an annual loss under this head of Rs. 38,236,000. Totalling these various headings we find the losses due to :

	Rupees
Crop-pests	1,800,000,000
Forest-pests	12,500,000
Human diseases	160,000,000
Animal diseases	38,236,000
	Rs. 2,010,736,000

or in all, say, in round figures two thousand millions (or two hundred crores) of Rupees every year. I do not think that these figures are at all exaggerated and it is needless to add that they disprove any idea that Entomology is a minor science of little practical importance. If we, by a study of insects and by practical application of the knowledge gained thereby, can save even one per cent. of this enormous wastage of the national wealth of India, such a saving would more than justify the most complete expansion of entomological work that we can possibly imagine.

"When I last addressed you two years ago, we met under the shadow of the Great War which had come to a close just before our Third Meeting and which for over four years had filled the newspapers with lengthy casualty lists and details of the great struggle. But we entomological workers are still living under the shadow of a Great War, a strife between the Insect World on the one side and Mankind and his possessions on the other, a Great War of Waste which is taking place every day not only in India but throughout the whole world and beside which the Great War of the Nations becomes almost insignificant when we reckon up the total losses on our side. Throughout the whole world mankind struggles to raise crops to provide food for his wants ; and in every country under the sun his crops are ravaged by insect pests and he himself and his domestic animals stricken with diseases carried by insects. To us, as entomologists, such a statement is a truism, although, as I have already said, few even of us realize the magnitude of the losses caused by insects, and I am far from wishing to emulate the Bellman by repeating :

'I have said it thrice :
'What I tell you three times is true.'

"However, as entomologists it behoves us to try to educate the General Public into some realization of the waste of national wealth due to insect pests, and it is with this object in view that I have addressed you on this subject."

The Meeting then proceeded to the reading of the various papers, of which fifty-one were offered for discussion. Section I,

dealing with Crop-pests, contained nearly a half of the total, twenty-two papers on various aspects of Economic Agricultural Entomology being put forward in this Section. Of these we have only space to notice a few. Additions and corrections to the list of Indian Crop-pests, summarizing the recent work of the Agricultural Department, were made by Messrs. T. Bainbrigge Fletcher, Ballard, Ramakrishna Ayyar and de Mello. A Crop-pest Calendar for Madras, showing the times and areas of occurrence of the principal pests, formed the subject of a paper by Mr. T. V. Ramakrishna Ayyar, and the ideas underlying this will probably prove capable of extension in other Provinces when further records are accumulated. Mr. Ballard gave an interesting account, illustrated by a detailed map and coloured poster, of a *Spodoptera* campaign in Malabar, and also an account of recent work in Madras on Pink Bollworm. Cotton-pests also provided subjects for papers by Messrs. Misra and Jhaveri, and three papers on Borers in sugarcane and other cereals summarized the work done at Pusa, in the Central Provinces and in Gujarat. Mr. Andrews, Entomologist to the Indian Tea Association, gave a further account of his attempts to produce immunity to attack of mosquito blight (*Helopeltis*) of tea by injecting the tea-bushes with potassium salts. A preliminary list of the Insect Pests of Mesopotamia, by Rao Sahib Y. Ramachandra Rao, proved of considerable interest, as it revealed the presence in Mesopotamia of several highly undesirable pests which we have not got as yet in India, and a paper by Messrs. Afzal Husain and Hem Singh Pruthi gave a detailed account of experiments on the use of different poisons against field-rats in the Punjab.

Section II dealt with Forest Entomology and included only one paper, by Mr. C. Beeson, Forest Zoologist, who gave an interesting account of recent work in Forest Entomology.

Section III included eight papers on Medical and Veterinary Entomology, of which no less than six dealt with mosquitos. Messrs. S. K. Sen and H. N. Sharma gave accounts of the effects of various chemical substances on the immature stages of mosquitos, and the same authors also read a joint paper on oviposition in

Culicidæ. Major S. R. Christophers, C.I.E., I.M.S., gave a very excellent paper on the geographical distribution of mosquitos in India, and this elicited a lively discussion on the natural means of distribution of insects, in which the probable importance of upper atmospheric currents was emphasized. Mr. M. O. T. Iyengar gave an illustrated description of a new thoracic appendage in Anopheline larvæ, and Mr. T. Bainbrigge Fletcher gave a short address on Mosquito Traps illustrated with examples of new forms of traps for adult mosquitos. Messrs. Bainbrigge Fletcher and Senior-White reviewed our present knowledge of the subject of Surra and Biting Flies and exhibited the Tabanid flies collected by Leese at Mohand in 1908. A paper by Messrs. Senior-White and S. K. Sen, on the occurrence of Coleoptera in the human intestine, dealt with some cases, reported from Bengal, of a disease, known also in Ceylon, in which the adult stage of a small dung-beetle has been found on several occasions in the human intestine ; this paper gave rise to a discussion of the means by which infection takes place.

Section IV, Household and Store Pests, contained only one paper, by Messrs. Afzal Husain and Harnam Das, on lethal temperature for some stored grain pests, and Section VI two papers on Lac by Mr. C. S. Misra.

Section VIII, Life-histories and Bionomics, accounted for nine papers, of which we can only find space to mention a few. Professor E. B. Poulton, D.Sc., F.R.S., contributed a further note on the proportions of the female forms of *Papilio polytes*, and a paper on protective movements and range of vision of Platypezid Flies was prepared from notes left by the late F. M. Howlett. The life-histories of some Celyphid Flies, whose early stages have not been detailed before, were described by Mr. S. K. Sen.

Section IX (Collection and Preservation of Insects) included only one paper, on setting without boards, Section X (Systematic Entomology) two papers on Coccidæ and parasitic Hymenoptera, and Section XI (Publications) the report of the Catalogue Committee. Under this last heading it may be noted that the project for the preparation and issue of a general Catalogue of Indian Insects, proposed at the Third Entomological Meeting, has now

received official sanction and that this work is being pressed on.

Section XII (Miscellaneous) is meant to include any subjects not provided for in other Sections and at the present Meeting this heading included four papers of which the first, on the practical application of Insect Psychology, had been prepared from notes left by the late F. M. Howlett and represented the lines on which he was working. Mr. C. Beeson gave an account of the Imperial Entomological Conference held in London in June 1920, and in this connection the Meeting passed an unanimous Resolution recording its appreciation of the work of the Imperial Bureau of Entomology and particularly of the assistance obtained from the *Review of Applied Entomology.* The only other Resolution passed by the Fourth Meeting endorsed the desirability of the publication in India of papers dealing with Indian insects sent out to specialists by Government Institutes in India.

The Entomologists were the pioneers of Sectional Meetings, of which they have now held four in the last six years, the First Meeting having been held in February 1915. It is therefore perhaps permissible to say that sufficient experience has been gained to assert that these Meetings have been thoroughly successful in fostering intercommunication between the various scattered workers on this subject and in cementing that spirit of " mutual confidence and mutual aid " by which, not only " great deeds are done and great discoveries made," but the individual workers themselves learn to feel that their efforts and aims form, or at least should form, a part of one harmonious mosaic, which itself represents the progress of scientific work for the commonweal.

A complete Report of the Proceedings has been sent in to press and will be published in due course.

REPORT ON THE FIRST ALL-INDIA EGG-LAYING COMPETITION.

CONDUCTED AT THE U. P. MODEL POULTRY FARM, LUCKNOW, BY THE UNITED PROVINCES POULTRY ASSOCIATION.

BY

MRS. A. K. FAWKES,

Secretary, United Provinces Poultry Association, and Poultry Expert to U. P. Government.

THE above competition is the first of its kind to be organized by Government and as such it has fully achieved its purpose. It was organized with a view to encourage the breeding of highly productive fowls, and, at the same time, to ascertain the winter laying capacity of such birds as should be sent to the competition to be tested. No less than 84 entries were received, and 55 of these, among them four from England, materialized. A great deal of interest was taken in the competition and the farm had constant relays of visitors, and very large entries are promised for next year.

The conditions laid down were, briefly, that only pullets hatched after 1st January, 1920, would be accepted, and fully matured and healthy birds allowed to enter.

The idea of the short test was to judge, by the bird's individual score during the first three months of its laying period, what kind of layer it would be likely to continue. In England a pullet laying an average of 30 to 40 eggs between October 15th to January 15th for a light breed, and the same amount between 15th November to 15th February for a heavy breed, would be considered to be a first-class layer, but this is probably not so in India, as many of the birds laid between 40 to 65 during the three months' test.

METHODS OF HOUSING AND FEEDING.

The competing birds were housed in single pens, each measuring six feet square and raised 18 inches off the ground, and the floor space was covered with river sand to the depth of nine inches. All the corn that was fed to the birds was buried in this sand, thus ensuring the necessary exercise. The houses were very airy and open, with wire netting on all sides, only the floor and roof being constructed of well tarred woodwork. At night light canvas shutters were put up as a protection. Only two deaths occurred, in spite of very cold nights and sudden extremes of temperature to which hens in high laying condition are very susceptible.

The birds were fed as follows :—Two ounces of mixed corn per bird was fed daily, the grain consisting largely of wheat, with a small quantity of such grains as split maize, grain, unhusked rice and millets added. This was given in the early morning, and at 3 P.M. a dry and crumbly mash was made of slightly scalded bran, cooked tripe of offals of sheep or goats, finely chopped and cooked vegetables (the liquor of the cooked meat and vegetables was used to scald the bran), and this mixture was dried off with coarse flour (*atta*) or barley meal. The meat formed 5 per cent. of mash and was gradually increased to 1 oz. per day per bird. Each bird had not less than 2 oz. of the soft food, and more was given if the birds seemed hungry. Freshly cut leaves of lucerne, country spinach, turnip tops, etc., were hung up in each pen daily for the birds to peck at. Powdered charcoal and shell grit were always before the birds. The pens were regularly sprayed with "Milton" disinfectant.

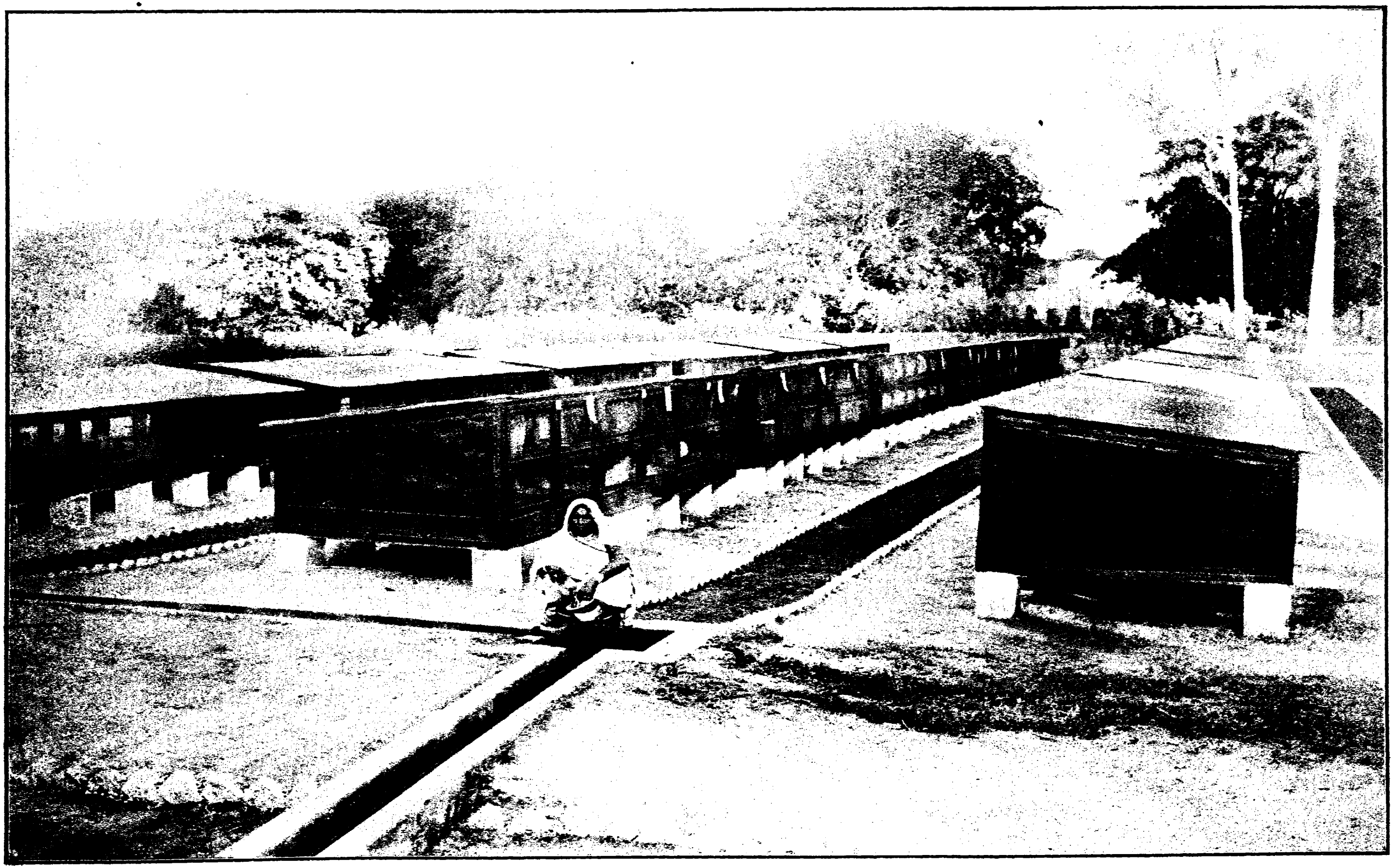
TEST AND RESULTS.

The 54 pullets were of various pure breeds as follows :—

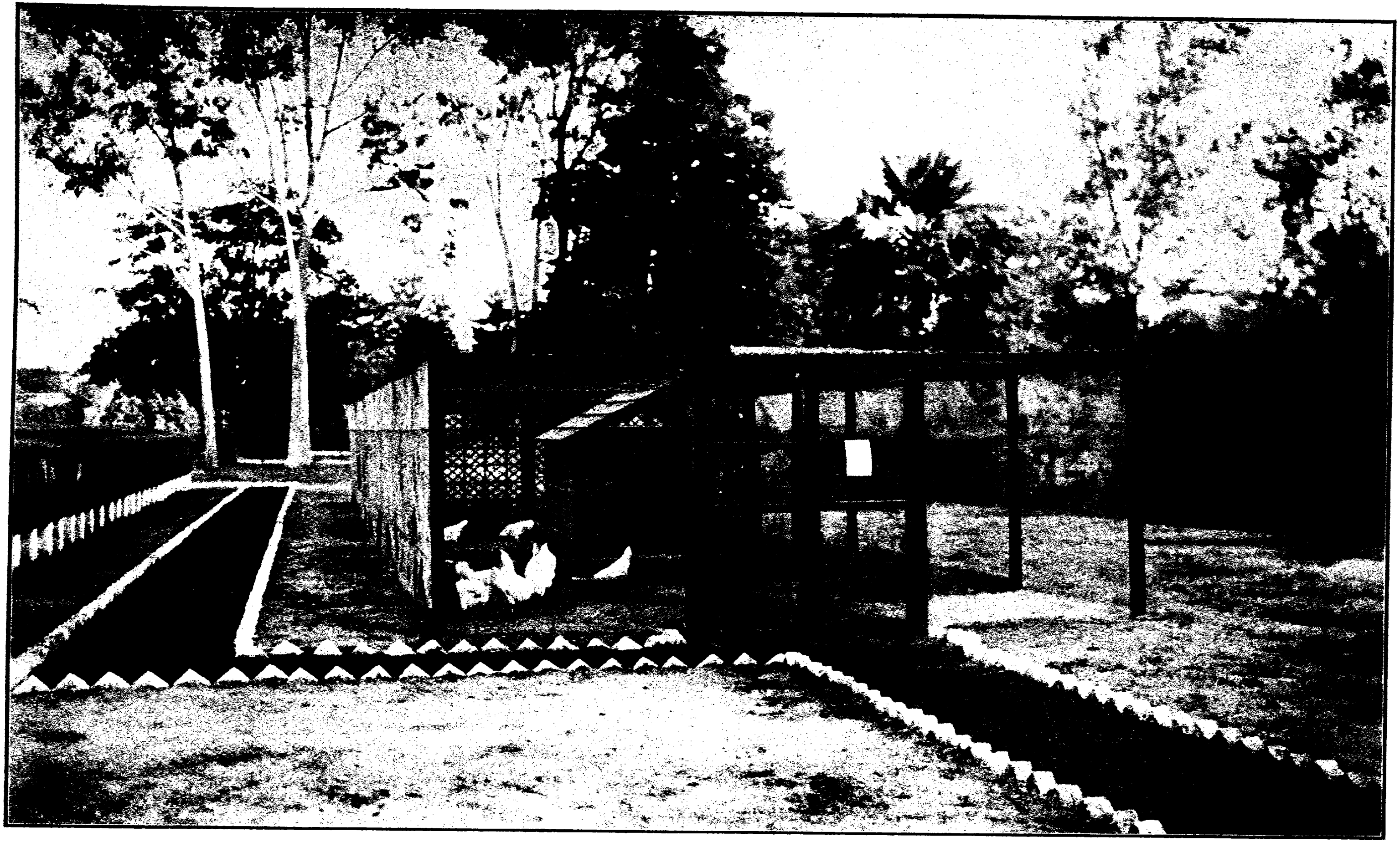
29 White Leghorns.
6 Black Leghorns.
5 White Orpingtons.
4 White Wyandottes.
10 Black Minorcas.

The grand total of eggs laid during the three months was 2,049.

PLATE XVI.



View of Single-Testing Pens used in the Egg-laying Competition, Lucknow, 1920-1921.



Pen of White Australian Leghorns, 300 eggs strain, imported by the U. P. Poultry Association.

The average per hen worked out at 37·25 eggs in the 92 days. This low average is accounted for by the fact that good and poor layers were sent. We hope this average will be much higher next year.

These 2,049 eggs, approximately 170 dozen, were sold for eating at the rate of Rs. 2 per dozen, thus realizing Rs. 340. Only 58 eggs were below 2 ounces, or an average of 1 second grade egg per hen, during the three months' test. The total weight of eggs was 4,210½ oz. (263 lb. 2½ oz.); this compares very favourably with the large numbers of second grade eggs laid in the laying tests of other countries, and India should endeavour to maintain this factor, as the weight is so essential to balance the small size of the egg of the country fowl. One hen laid 47 eggs weighing 7 lb. 7¼ oz., only 1½ oz. less than the best layer in the test, whose total was 65 eggs weighing 7 lb. 8¾ oz. This pullet was a White Leghorn owned by Mr. A. C. Bullmore of Madras. She weighed under 4 lb. She secured His Excellency the Governor's cup for the best layer in the competition. The cost of feeding the birds amounted to Rs. 101, the cost of labour was Rs. 54, a total expenditure of Rs. 155. The profit balance plus the entry fees of Rs. 3 per bird was expended in handsome awards to the winning birds. Other costs were borne by the United Provinces Poultry Association.

Record of test pens.

Pen	Breed of pullet	Name of owner	No. of eggs laid	Description of prize awarded
1	White Wyandotte	Mrs. Lane	4	
2	Do.	Do.	29	
3	Black Leghorn	Do.	died	
4	Do.	Do.	52	
5	White Leghorn	Mrs. Tilley	52	
6	Do.	Do.	36	
7	Do.	Do.	37	
8	Do.	Do.	10	
10	White Orpington	Mrs. Lambert	31	
11	Do.	Do.	0	
12	White Leghorn	Do.	52	
13	Do.	Do.	57	Best layer owned by a resident of the U. P.

RECORD OF TEST PENS—*Concld.*

Pen	Breed of pullet	Name of owner	No. of eggs laid	Description of prize awarded
14	White Leghorn	Mrs. Richardson	38	
15	Do.	Do.	34	
20	Black Minorca	Mr. Beck	23	
21	Do.	Do.	17	
24	White Orpington	Mr. Brewin	51	Best layer of White Orpington breed.
25	Do.	Do.	41	
26	Do.	Do.	48	
28	White Leghorn	Mr. Green	27	
31*	Do.	Mr. Bullmore	63	
32*	Do.	Do.	65	The best layer among White Leghorns, and also in the whole competition. Awarded H. E. the Governor's cup.
33*	White Wyandotte	Do.	60	Best layer among White Wyandottes.
34*	Do.	Do.	49	
35	White Leghorn	Mrs. Peychers	49	
36	Do.	Do.	32	
37	Do.	Do.	47	Layer of heaviest eggs.
38	Do.	Do.	44	
41	Black Minorca	Mrs. Morbey	44	
42	Do.	Do.	39	
43	Do.	Do.	38	
44	Do.	Do.	41	
47	Do.	Mrs. Johnson	50	Best layer of Black Minorca variety.
48	Do.	Do.	28	
49	White Leghorn	Mr. H. F. Baker	43	
50	Do.	Do.	50	
51	Do.	Do.	44	
52	Do.	Do.	52	
57	Do.	Mrs. Desmier	32	
58	Do.	Do.	34	
59	Do.	Do.	28	
60	Do.	H. S. Khan	14	
61	Do.	"O. B. K."	32	
62	Do.	Do.	23	
63	Black Minorca	Do.	46	
64	Do.	Do.	47	
67	Black Leghorn	Mr. B. R. Splane	14	
68	Do.	Do.	5	
69	Do.	Do.	58	Best layer of Black Leghorns.
70	Do.	Do.	25	
113	White Leghorn	Mr. Alfred Brown (England)	44	
114	Do.	Do.	35	
115	Do.	Do.	40	
116	Do.	Do.	54	Best layer sent from overseas.

* Four best pullets in the competition.

Certificates of first class merit were awarded to the birds who laid 50 eggs or over, and of second class to those who laid 40 to 49 eggs.

Selected Articles

THE GROWTH OF THE SUGARCANE.*

BY

C. A. BARBER, C.I.E., Sc.D., F.L.S.

VIII.

DIFFERING radically from the length of the cane, the thickness is, within certain limits, fixed for each variety. We have thick, medium and thin forms, and the thickness attained by individual canes is not nearly so much influenced by climatic and other external conditions as is their length, which we discussed in last month's paper. An ordinary sugarcane in the field will have a thickness of from $1\frac{1}{2}$ to 2 inches, but there are two classes in which these limits are overstepped. Here and there throughout the sugar belts we meet with very thick-stemmed varieties, sometimes distinguished as "elephant" canes. Taking the Tanna series as examples, the following are characters which distinguish them. They do not grow too tall for ease in reaping, do not fall easily and are markedly resistent to the commoner cane disease : there are comparatively few canes in the bunch but the tonnage is good ; they are self-cleaning, in that the dead leaves readily fall off. On the other hand, the juice is rather poor and elephant canes are not usually in much favour on the estates : they are sometimes found troublesome in the mill because of their great thickness. This is of course especially the case with the primitive bullock crushing mills, where it is not uncommon for the canes to be sliced in half before pushing between

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* Reprinted from *The International Sugar Journal*, August 1920.

the rollers, owing to the heavy work devolving on the cattle. In spite of these disadvantages, the Tanna canes appear to have been received with favour in certain localities and the yield is often very heavy. In parts of Bengal and Bihar, where lodging is a serious drawback in the light alluvial soils, especially when the fields are flooded by the monsoon rains, these canes can be seen standing up handsome and pillar-like among the falling thinner varieties. Elephant canes, which are usually from two to three inches in thickness, are an interesting class but cannot be regarded as in any sense the climax of selective development. It is, indeed, arguable that, among the cane varieties most valued on estates, the trend is rather in favour of the thinner than the thicker forms, a point of view to which we shall refer later on.

In marked contrast to the elephant canes are the varieties indigenous in India. Although a few of these, such as Mojorah of Assam, may rival in thickness the tropical varieties, it is usual to designate the latter as the "thick cane" series. Most Indian canes are well under an inch in thickness and some are very much thinner. For instance, it is probable that the great bulk of the canes reaped from the 400,000 acres of sugarcane in the Punjab are distinctly less than half an inch in diameter, besides having a thick, tough rind and much fibre. Indian canes are frequently classified under three classes, Ukh, Ganna and Paunda, although this classification is more suitable to the canes in the United Provinces (where it arose) than elsewhere. The Paunda canes are from 1½ to 2 inches in diameter and are probably all introduced tropical canes, some of them having been in the country for a long period. The Ukh varieties form the mass of canes grown in the north of India and are present in an enormous number of varieties separable into several great groups. They are, like the Punjab canes, thin and fibrous, but the juice, such as there is of it, is sweet. Between these two classes are the Ganna canes, generally from one-half to one inch in diameter, with less fibre and more juice than the Ukh canes, but this juice is of poorer quality ; they are, further, less hardy and more liable to diseases such as red rot, and, in consequence, have greatly diminished in favour during the

PLATE XVIII.

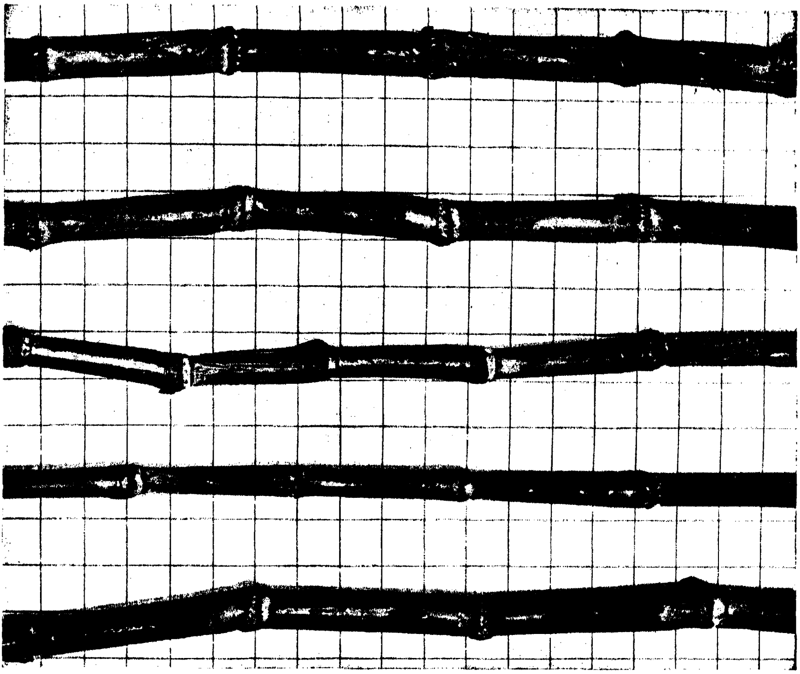


Fig. 2. Pansahi Cane from Bengal.

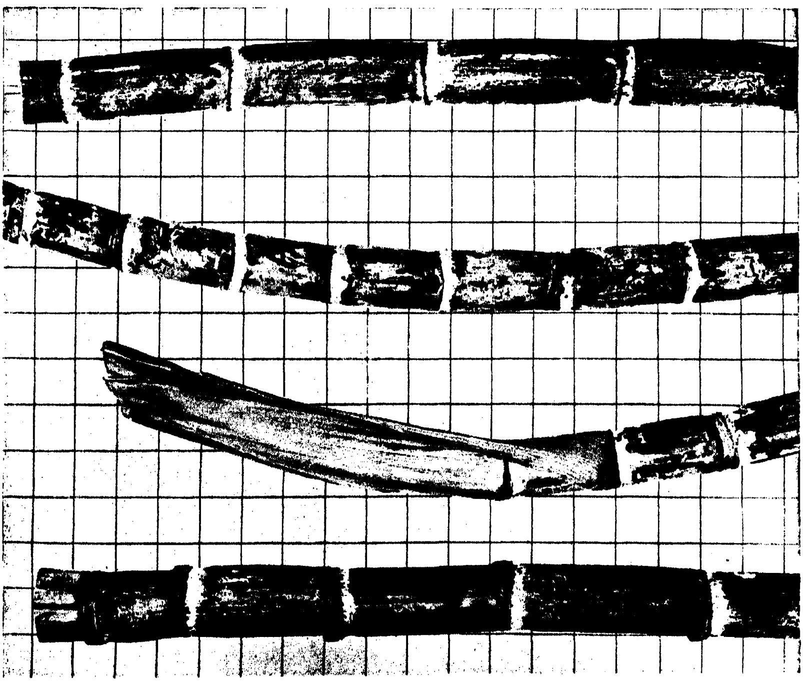


Fig. 1. Chittan Cane from Madras.

Fig. 1. Katha Cane from the Punjab.

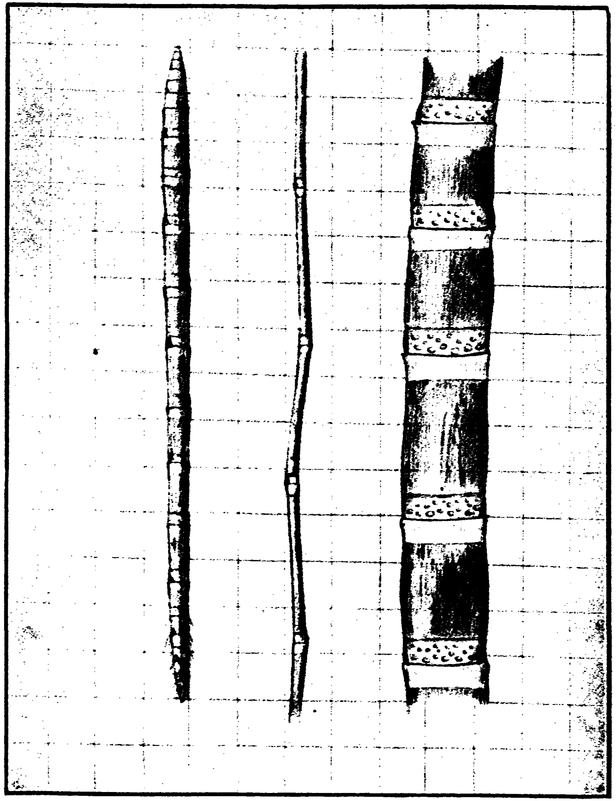


Fig. 2. Some tiny Ukh Canes taken from the mill yard, compared with a Paunda Gane.

last half century. They belong to several well defined groups, of which the most interesting, from our point of view, is the Pansahi, with perhaps twenty varieties, for to it undoubtedly belong the Uba cane of Natal and the similar varieties of South America though how and when they were transferred from India has not as yet been determined.

This opportunity is taken to illustrate the relative size of the typical Paunda, Ganna and Ukh canes grown in India. Figure 2 on Plate XIX is added to show what tiny specimens are occasionally crushed in the mills. All the pictures are drawn or photographed on inch squares. Plate XVIII, fig. 1, is of a Chittan cane from Madras, a typical Indian Paunda variety. Figure 2 on Plate XVIII is of Pansahi from Bengal, a typical Ganna cane. Figure 1 on Plate XIX is one of Katha from the Punjab: an average cane of the main Ukh variety grown in the tract. Plate XIX, fig. 2, lastly, shows some canes collected by the writer from the mill yard in India. On the right is a specimen of the ordinary Paunda canes grown. In the middle is an Ukh specimen collected in North India: it was not an average cane, but one of many of similar diameter being crushed. On the left is an *average* specimen taken from a ton of canes just arrived at the mill from a poor field of ratoons: it measured, all over, from base to apex, only 14 inches, and was collected because of its unusually meagre proportions. One specimen, only 8 inches long, was at first taken off the cart, but was rejected as distinctly below the average. It seems strange that it should be worth while to crush such canes, but I was interested to learn that the season's work turned out to be very profitable to the mill concerned.

Taking thickness into consideration, there is yet another class of canes which deserves mention here, namely, the seedling canes which have been obtained during recent years by crossing thick tropical forms with the thin Indian canes. Such are the Java seedlings Nos. 33, 36, 139, 213 and so on, obtained by crossing Cheribon with Chunnee, hardy, free tillering, thin canes which have met with much acceptance in places where the climate is unsuitable for the growth of the more delicate tropical kinds, especially in Argentina and

different parts of India. Many similar crosses between indigenous Indian canes and those of the tropics have recently been raised at the Cane-breeding Station at Coimbatore, and these have now been distributed and are entering into competition with the North Indian forms which they are designed to displace. Lastly, there is a curious set of seedlings, also emanating from Coimbatore, which closely resemble these crosses but have apparently no Indian blood in them. Whenever large blocks of thick cane seedlings have been raised, one or two have been noted with much thinner stems, but amazing vigour and hardiness though poor in juice withal. In spite of the last named defect, they have been carefully reproduced and have been largely used to cross with thick canes to obtain a special blend of hardiness with moderately good juice. Some of the seedlings thus raised are among the most promising which the Station has sent out. Owing to their peculiar and little understood mode of origin these aberrant seedlings have been termed "rogues."

Turning to the growth in thickness of the individual sugarcane, we have seen in former papers that each stalk arises from a bud and is extremely thin at its junction with the parent stem.[1] The joints, once formed, do not themselves increase in thickness, and for this to take place in the canes each succeeding joint is broader than its predecessor until the thickness usual for the variety has been attained, after that the new joints remain of this thickness but greatly increase in length, so that the cane is pushed up pillar-like without any alteration in its diameter. In this matter the cane resembles the palms, whose tall stems are usually of a uniform thickness all the way up. There is no secondary thickening of the stem such as we are accustomed to in the trees of temperate regions, owing to the absence of any cambium layer. Toward the summit of the cane the thickness rapidly diminishes among the immature joints and the cane ends in a conical apex. We can thus prepare a section of the whole cane and compare it with a cylindrical rod with pointed ends. (Plate XIX, fig. 2.)

[1] *The Agri. Jour. of India*, Vol. XV, No. 2; *Ibid*, Vol. XVI, No. 1.

But while this may be taken as the normal course of events, a more detailed study of the thickness of the cane in different parts shows certain exceptions. The first formed canes of a bunch are often thinner in their lower part and become gradually thicker upwards, sometimes ending club-like before the final narrowing at the apex. On the other hand, the latest formed canes of the clump are often enormously thickened at the base and quickly narrow upwards. This latter peculiarity is specially met with in those abnormally thick late shoots which have not time to ripen before harvest and are termed gourmandizers or water shoots. Most canes, furthermore, are not strictly cylindrical, but oval in section, being wider in the median plane (that in which the row of buds lies) than in the lateral. And an extreme case of ovalness has been met with in certain varieties, in that the basal part of the cane is literally flattened out, and in the lateral instead of the median plane, and does not reach its comparatively cylindrical form for some way up. Such exceptions need not interfere with our general conception of the growth in thickness and form of the cane, and are merely mentioned here to emphasize the point that, in every case where detailed study is made of any natural phenomenon, exceptions are found which are paradoxically claimed to "prove the rule" by their very rarity.[1]

In the opening sentence of this article we spoke of "certain limits" within which the normal thickness of the canes in any one kind of cane will vary. Everybody watching the canes passing up the carrier to the mill will have noted that, while there is a general average thickness in each kind of cane, many isolated canes either exceed or fall short of it. The cause of this constant variation has been somewhat fully explained in previous papers of this series (*see* especially *The Agri. Jour. of India,* Vol. XV, pp. 652-653 and the figures on the accompanying plate). Stating the case briefly, we know, from our dissections of the branching system of the cane plant, that those first appearing are

[1] C. A. Barber. "Studies in Indian Sugarcanes, No. 4." *Mem. Dept. Agri. India, Bot. Ser.* X, 2, 1919, page 126. *See* also in the same paper Plate XVII where the usual form of basal thickening of the cane is clearly shown.

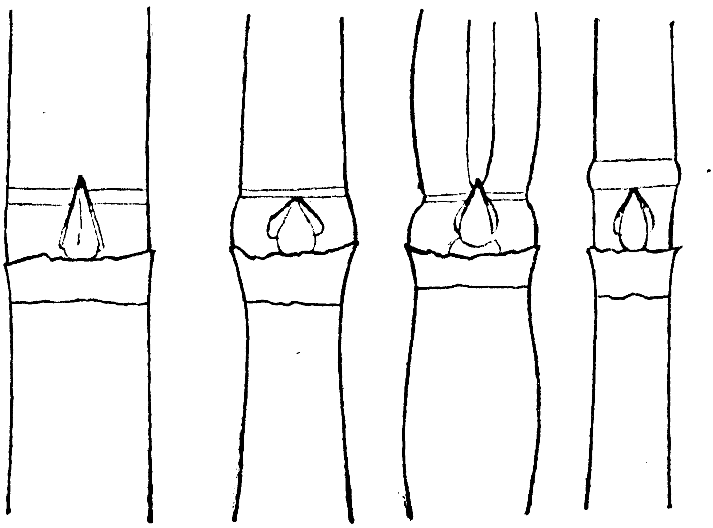
usually the thinnest, and that the later formed branches are thicker and thicker according to the order of branching they represent in the clump complex. With the normal thickness of the variety in one's mind it is thus easy, at the mill, to separate the canes into those formed in the early and late parts of the season. And the limits of variation around the normal or average will depend upon the formula of the branching system[1], being wide in the case of canes with an extended formula, such as the Indian canes, and narrower where, as in the tropical forms, there are fewer canes in the bunch and the formula has fewer orders of branching.

We have thus far considered the thickness of the cane as a whole and studied its variations in different parts, assuming that each joint is uniform throughout its length. This is, of course, not the case. While the joints of some canes are almost uniformly cylindrical, those of others differ in thickness in different parts of the length, this giving them a characteristic *shape.* In some canes the joint is thickest at the node, and it becomes bone-shaped or biconcave; in others the joints are thickest in the middle and are biconvex or barrel-shaped. Sometimes the base of the joint is thickest and the rest tapers upwards, and sometimes the reverse is the case ; and there are endless minor variations of these main types. The interesting feature in these joint shapes is that they are usually constant for the variety, and we have some reason to believe that the shape of the joint is one of those few characters of the cane which we know are handed down from parent to offspring.[2] The shape of the joint has already been found usefulin determining the male parentage of an unbagged seedling, when several adjoining plants have been in flower together. The text-figure on next page shows some typical shapes of cane joints.

The thickness of the cane is an important factor in the weight of the crop, and the question naturally arises as to whether we can in any way control it. A good deal of work has been done at various times in planting the cane sets at different distances apart, as

[1] *The Agri. Jour. of India,* Vol. XV, No. 4.
[2] *The Agri. Jour. of India,* Vol. XVI, No. 1.

influencing, amongst other things, the weight of the individual canes. Many years ago, Stubbs in Louisiana showed that, by planting the sets more widely apart, thicker canes could be obtained. This question has been more exhaustively studied in Java. There it became a matter of some importance to use as few sets as possible per acre, because, at the onset of the sereh disease, the planting material had to be raised in special hill nurseries far from the plantations in the plains. Muller Von Czernicki has published the most useful and comprehensive studies on the subject.



Some shapes of cane joints.

His results agree in the main with those of Stubbs as to the effect of spacing, and he showed that for each variety experimented with there is an optimum of cane reaped, which can be obtained by regulating the distance of the cane plants from one another in the rows. This matter of spacing is a suitable subject for experiments by planters, for no general rule can be formulated. The optimum of yield has to be determined for each variety grown, for each soil and treatment, and for all of the various factors influencing cane growth, such as constantly differ from estate to estate and even from field to field. In these days of intensive work in the factory, cultivation is liable to be somewhat neglected, but it is perhaps more by a careful

study of the work in the plantation than anything else that the value of the crop can be increased. That the variations in thickness may be considerable is evident from the following data published by the observers quoted above. Stubbs planted his sets 18, 12, and 6 inches apart in the rows, and the resulting average weights of the individual canes at harvest were 2·60, 2·49, and 2·17 lb., respectively. Muller Von Czernicki varied his distances by planting from 8 to 18 sets in the same length of row, and found that the weight of cane in the more sparsely rows exceeded those in the more closely planted by as much as 14 per cent. Although the weight of cane may depend equally on its length and thickness, and measurements of the former are not given by these observers, Muller Von Czernicki carefully measured thousands of canes as to individual thickness, and came to the conclusion that this was the chief factor in the case. All other workers agree that wider spacing produces thicker canes.

But, for a true estimate of the value of a crop, we must have some knowledge of the sugar content of the canes at harvest, and many investigators have tackled this problem, unfortunately, without knowing the way in which the cane plant was made up. They generally agree that the thicker canes of a crop have the purest juice. But the results here are less convincing; we now know that the thicker canes are those formed towards the end of the season, and that the relative richness of the juice in early and late canes will depend upon the period of growth at which the cane is out, opening up a further fruitful field for inquiry.[1]

In concluding these remarks on the thickness of the cane, we may add a few words on another problem well worth investigating, namely, have the thicker or thinner varieties of canes the richer juice? We have found that the purity of the juice of seedlings depends directly on that of their parents; the descendants of rich canes will, on the average, have rich juice and the converse. We have also observed that, when canes are crossed, the average sucrose percentage in the juice of the seedlings varies around the mean of

[1] *The Agri. Jour. of India,* Vol. XV, No. 6.

that of their parents. In judging the relative richness of the juice of thick and thin varieties, we must therefore confine our comparison to seedlings of the same parentage. As the results of many hundreds of observations we have come to the conclusion that, as a rule, the extremes of each series are worthless from the sugar point of view. Excessively thick or thin seedlings of a series generally have juice considerably poorer than the average. In a general collection of seedlings with common parentage, we have not been able as yet to come to any definite conclusion, although there seems to be a well defined tendency towards the thinner seedlings being slightly richer in juice than the thicker. In crossed seedlings, where a thick tropical cane has been crossed with a thin Indian one, there is an equally well-defined tendency in the opposite direction, the thicker seedlings of the series having slightly richer juice than the thinner.[1]

[1] This subject has been more fully developed in "Studies in Indian Sugarcanes, No. 2." *Mem. Dept. Agri. India, Bot. Ser.*, VIII, 3, 1916, pp. 178-179.

A STUDY OF THE INDIAN FOOD PROBLEM.*

BY

DAYA SHANKAR DUBEY, M.A.,
Scholar in Economics, University of Allahabad.

INTRODUCTION.

THE object of this paper is to make an impartial study of the food problem of this country with a view to finding out its total requirements of food-grains and the total supply of the same from the statistics that are at present available. In 1870, Dr. Dadabhai Naoroji, in his book "Poverty and UnBritish Rule in India," tried to show that the masses of Indian population were existing at that time in a condition verging on starvation. Sir W. Hunter, in his book "England's Work in India," observed that a fifth of the population (or 40 millions) went through life on insufficient food. In 1901, Mr. William Digby, in his book "Prosperous British India—a Revelation," reached much the same conclusion as Dr. Dadabhai Naoroji as to the starving condition of the Indian masses. More than 18 years have passed since the publication of the last named book, and the condition of the Indian people has undoubtedly changed a great deal; but till lately no attempt has been made to make a thorough and exhaustive study of this problem in the light of information which is now available.

Divergent views are held regarding the condition of the Indian masses. Many Indian thinkers, whose opinion is entitled to much

* Reprinted from *The Ind. Jour. of Eco.*, Vol. III, Pt. 1.

weight, hold that the condition of the Indian masses is going from bad to worse, the majority of them being under-fed, with the result that their physical condition is deteriorating ; while others, who are equally important personages, hold just the opposite view. Food being a vital necessity of life, the importance of the problem of finding out the extent of semi-starvation in India at the present time cannot be over-estimated ; and it is high time that some impartial and exhaustive inquiry should soon be undertaken. Recently Rai Bahadur Ganga Ram, C.I.E., M.V.O., late of the P. W. D. (Irrigation Branch), a bold and successful farmer of the Punjab, has attempted to tackle this problem very ingeniously in the first chapter of his interesting and useful little book "The Agricultural Problems of India" ; and after a careful calculation he comes to the conclusion that 77 million tons of food-grains were required in India during the year 1912-13, whilst the harvests of that year produced 76·36 million tons. Although the Rai Bahadur has opened up an important line of statistical inquiry, I strongly feel that the subject has not been dealt with as exhaustively as it ought to be to enable us to arrive at any satisfactory conclusion regarding this all important question. I, therefore, venture to deal, in the following few pages, with the same problem practically on similar lines.

THE EXTENT OF THE INQUIRY.

At the outset it must be made clear that I think it necessary to confine the inquiry to British India only, because agricultural statistics for all Native States are not available, and the agency for collection of statistics in most of those Native States for which agricultural statistics are available is not so trustworthy as that in British India.

THE NATURE OF THE INQUIRY.

The inquiry naturally falls under two heads. Under the first we have to consider the total requirements of food-grains by adding up (*a*) the quantity of food-grains required by the whole population, assuming them to have sufficient food to maintain them in health

and strength; (*b*) the quantity consumed by cattle, and (*c*) the quantity required for seed. Under the second we have to consider the total supply of food-grains by first finding out the total outturn of all the food-grains and pulses, after making due allowance for wastage; and then adding the excess of imports over exports of food-grains from and to Native States, and subtracting the excess of exports over imports to and from foreign countries.

THE PERIOD OF THE INQUIRY.

It is a well-known fact that harvests in India fluctuate much from year to year, and that stocks of grain are commonly carried over from one year to another; and so, in order to arrive at a trustworthy result, the inquiry must be extended over a sufficiently long period so that it may include ordinary, good and bad years from the agricultural point of view. Therefore, before entering on the first part of the inquiry, it is necessary to decide the period of inquiry and to ascertain the agricultural condition of each year. In my opinion, seven years' time is a sufficiently long period to give us a fairly good average, and I have decided to confine the inquiry to the period commencing from the year 1911-12 and ending with the year 1917-18.

AGRICULTURAL CONDITION OF DIFFERENT YEARS OF THE PERIOD.

Now the next step is to ascertain the agricultural condition of all these years. During 1911-12 winter rains had been favourable and, with the exception of a few afflicted tracts of Gujarat and Kathiawar, the year viewed as a whole was an ordinary one. In 1912-13 there was a good monsoon rainfall, but there was a slight failure of winter rains, particularly in Northern India, and so the year as a whole was an ordinary one. In 1913-14 the monsoon, after the middle of July, was irregular and the rains in the United Provinces and Central India ceased in early September. In parts of Bengal, Bihar and Orissa, and Madras, excessive rain resulted in heavy floods. The winter rains were also deficient in the United

Provinces, Central India and Rajputana, and famine conditions were established in parts of those provinces, and therefore from an agricultural point of view it was a bad year. In 1914-15 the monsoon was favourable for the autumn crops except in parts of Northern and Western India. The winter rice crop was adversely affected in some parts, and the conditions for wheat were favourable except in Bihar and Orissa and Bengal. Rain and hail caused some damage to the crop, but on the whole the spring crop was good, and so the year may be taken to be an ordinary one. In 1915-16 weather conditions were not altogether favourable owing to a weak and irregular monsoon and inadequate and untimely winter rains particularly in Northern and Western India. There were serious and disastrous floods in Assam and in parts of Bengal and the United Provinces, and so it was a slightly bad year. In 1916-17 the monsoon was remarkably vigorous and gave abundant rainfall throughout the country. It arrived early and continued late, the distribution of rain being remarkably uniform, and so this year was an exceptionally good one. In 1917-18 the south-west monsoon was exceptionally bountiful and prolonged, but winter rains were defective in the north and centre of India and, speaking generally, the copious south-west monsoon rendered this deficiency far less serious than otherwise would have been the case, and so this year was an ordinary one. So we see that, in the period under inquiry, we had four ordinary years, two bad years, and one good year.

QUANTITY OF FOOD-GRAINS REQUIRED PER HEAD PER DAY.

Now I turn to the first part of the inquiry. First of all, we have to find the quantity of food-grains required by the whole population of British India, assuming them to have sufficient food to maintain them in health and strength. For this purpose we have to determine the quantity of food-grains and pulses daily required by ordinary men to maintain them in health and strength under different age groups. Now the latest Famine Codes of the United Provinces, the Punjab, Bengal, Bombay and Madras give the following wage scale, which is worked out on the principle that the famine

wage should be the lowest amount sufficient to maintain an ordinary man in proper health.

	Chhataks *
Workers—	
Diggers	18
Carriers	14
Working children	10
Dependents—	
Adult (males)	12
,, (females)	10
Children (10–14)	8
,, (7–10)	6
,, (under 7)	4
,, (in arms) (to the mother, ..	3

* 1 *Chhatak*=2·057 oz.

It is further mentioned in the United Provinces, the Punjab and Bombay Codes that, if cooked food is given, the price of the ration, including the allowance of salt, oil, condiment and fuel, etc., should equal the price of the grain allowance prescribed in the above table which includes the margin for these articles also ; and the Bengal Code says that if cooked food is given the allowance for grain should be reduced in the case of workers and adult dependents by two *chhataks*, and in the case of children from 14 to 7 by one *chhatak*. The reduction may be taken as representing the amount of pulse, salt, *ghee*, condiment and vegetables which should form part of the ration. So the rations of food-grains for cooked food, excluding pulse, given in addition to that of vegetables and other articles according to the above-mentioned Famine Codes, would stand as follows :—

	Chhataks
Workers—	
Diggers	16
Carriers	12
Working children	8
Dependents—	
Adult (men)	10
,, (women)	8
Children (14–10)	7
,, (10–7)	5
,, (under 7)	4
,, (in arms) (to the mother) ..	3

After making an allowance for pulse of one *chhatak* per day for adults and half a *chhatak* per day for children above 10 and turning *chhataks* into ounces at the rate of 2·057 ounces for one *chhatak*, the above may be represented in a slightly different manner as follows :—

Quantity of food-grains excluding vegetable required per head per day.

Age	oz.
0 to 1	6·2 (in arms) (to the mother)
1 to 2	6·2 " " "
2 to 5	8·2 (under 7)
5 to 10	10·3 (from 7 to 10)
10 to 15	15·4 to 17·5 (from 10 to 14 and working children)
15 to 50 (males : workers) ..	35·0 (Diggers)
15 to 50 (males : non-workers) ..	22·6 (Dependent adult-men)
15 to 50 (females : workers) ..	26·7 (Carriers)
15 to 50 (females : non-workers) ..	18·5 (Dependent adult-females)

The Central Provinces Famine Code of 1896 gives the following full ration of food-grains and pulses for able-bodied persons :—

	For a man	For a woman
	oz.	oz.
Flour of common grain used in country or clean rice	24	20
Pulses	4	4
Salt	½	½
Ghee or oil	1	½
Condiments and vegetables	1	1

For children, ¾, ½ and ¼ according to age and requirements.

The above may be represented as follows :—

Quantity of food-grains and pulses excluding vegetable required per head per day.

Age	oz.
0 to 1	..
1 to 2	..
2 to 5	7
5 to 10	14
10 to 15	21
15 to 50 (males)	28
15 to 50 (females)	24

In the Central Provinces Jail Manual it is expressly stated that all native prisoners shall have three meals a day—in the early

morning, at mid-day, and in the evening—and the diet scale shall be as follows :—

	For labouring male convicts	For non-labouring male convicts, male prisoners undergoing simple imprisonment, and female prisoners of all classes
	Chhataks	*Chhataks*
EARLY MORNING—		
Rice, or	2	$1\frac{1}{2}$
Wheat or *Juar* flour	$1\frac{1}{2}$	1
Molasses	$\frac{1}{2}$	$\frac{1}{2}$
Salt	$\frac{1}{16}$	$\frac{1}{16}$
MID-DAY AND EVENING—		
Rice, or	11	9
Wheat flour, or	10	8
Juar flour, or	11	9
Rice and flour	11	9
Dal	3	2
Vegetables	3	3
Oil	$\frac{1}{4}$	$\frac{1}{4}$
Salt	$\frac{5}{16}$	$\frac{1}{4}$
Condiments	$\frac{1}{8}$	$\frac{1}{8}$

From the above we find that the quantity of food-grains and pulses given, in addition to vegetables and other articles, to prisoners in the jails of the Central Provinces works out as follows :—

Adult (males) workers, 20·8 ounces (for labouring male convicts)
,, ,, non-workers, 22·6 ounces (for non-labouring male convicts)
,, females, 22·6 ounces (for female prisoners of all classes)

According to the Jail Manual of the United Provinces, all Indian adult male prisoners sentenced to rigorous imprisonment, and all adult Indian male prisoners sentenced to simple

imprisonment who elect to labour, get their food in jails according to the following diet scale :—

	Chhataks
Cereal pulse combination	14
Dal	1
Vegetable	3
Oil	$\frac{4}{25}$
One chilli	
Salt	*Grains* 150
Coal (charcoal)	*Chhataks* 2 to 3

The dietary of all adult Indian female prisoners sentenced to rigorous imprisonment, and all adult female prisoners sentenced to simple imprisonment who elect to labour, and all juvenile prisoners arrived at puberty, is regulated according to the following diet scale :—

	Chhataks
Cereal combination	12
Dal	1
Others as above	

And the diet scale of all Indian adult prisoners sentenced to simple imprisonment who do not elect to labour, all juvenile prisoners not arrived at puberty, and all undertrial prisoners, is as follows :—

	Chhataks
Cereal combination	10
Dal	1
Others as above	

It is also stated in the same Manual that "children under two confined along with their mothers should have a diet allowance as under :—

(*a*) to nursing mothers two *chhataks* of wheat *atta* and half a *chhatak* of *ghee* in excess of the ordinary labouring rations ;

(*b*) to children between 12 and 18 months six *chhataks* of milk, two *chhataks* of rice, and half a *chhatak* of *dal* ;

(*c*) to children between 18 and 24 months four *chhataks* of milk, four *chhataks* of rice, and half a *chhatak* of *dal.*"

From the above it can be seen that the quantity of food-grains and pulses given per day to Indian prisoners, in addition to vegetables and other articles, in the jails of the United Provinces is as follows :—

Age	oz.
0 to 1 (to the mother)	2·1
1 to 2	5·1 to 9·3
2 to 5	(*a*)
5 to 10	(*a*)
10 to 15	22·6
15 to 50 (males : workers)	30·8
15 to 50 (males : non-workers)	22·6
15 to 50 (females : workers)	26·7
15 to 50 (females : non-workers)	22·6
Above 50	22·6

(*a*) Information not available.

The hospital full diet scale as given in the Jail Manual of the Central Provinces is as follows :—

	Chhataks
MORNING—	
Suji (flour)	1
Milk	2
Sugar	$\frac{1}{4}$
MID-DAY AND EVENING—	
Wheat flour, or	10 }
Rice, or	11 }
Wheat and rice	11 }
Dal	3
Vegetables	3
Oil	$\frac{1}{4}$
Salt	$\frac{5}{16}$
Condiments	$\frac{1}{8}$

From the above we find that for a full diet in hospitals of the Central Provinces 30·8 ounces of food-grains and pulses are given in addition to vegetables and other articles.

In "Land and Labour of a Deccan Village" by Dr. Harold Mann on page 134 we find that the following ration for a family

of five persons composed of one man, two women, and two children was considered as the minimum by the people themselves.

Material	Quantity required per annum
	lb.
Bajri	2,304
Rice	48
Pulses	80
Wheat	48
	2,480

If we count a woman as requiring four-fifths, a child three-fifths the food of a man, as Dr. Harold Mann has done, we find that the above rations come to 28·6 ounces per day for an adult male, 22·9 ounces per day for an adult female, and 17·2 ounces per day for a child.

All these various figures have been placed side by side in the table on next page; and assuming the number of adult male workers to be three-fourths of the adult male population, and of adult female workers to be one-third of the adult female population, I have calculated the average standard from all these figures. It is given in column 8 of the table.

Statement showing the quantity of food-grains and pulses required by able-bodied persons per head per day (in addition to vegetables and other articles) to maintain them in health and strength.

Age	Ration of food-grains and pulses for cooked food from the U. P., Punjab, Bombay, Bengal and Madras Famine Codes	Full ration from the C. P. Famine Code of 1896	Jail ration from the C. P. Jail Manual	Jail ration from the U. P., Jail Manual	Hospital full diet ration from the C. P. Jail Manual	Calculated from figures given in Dr. H. Mann's book	Average of columns 2 to 7	Standard adopted for the inquiry	Rai Bahadur Ganga Ram's standard*
1	2	3	4	5	6	7	8	9	10
	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.
0 to 1	6·2 to the mother	..	..	2·1 to the mother	..	..	4·1	nil	1
1 to 2	6·2 „ „	..	..	5·1 to 9·3	..	..	6·9	5	2
2 to 5	8·2	7	..	....	..	..	7·6	8	3 to 5
5 to 10	10·3	14		....	..	17·2	13·8	12	7
10 to 15	15·4 to 17·5	21	..	22·6	..		18·7	16	9
15 to 50 (males : workers) ..	35·0	28	30·8	30·8	30·8	28·6	29·8	28	25
„ (males : non-workers) ..	22·6		22·6	22·6					
„ (females : workers) ..	26·7	24	22·6	26·7	30·8	22·9	23·6	24	17
„ (females : non-workers) ..	18·5			22·6					
Above 50	....	..	..	22·6	..	..	22·6	20	13

* These figures include an addition of one ounce per head per day which represents an allowance made by him for confectionaries, etc.

After taking into consideration the population at different age-groups, the weighted average of this average standard for the whole population comes to 20·8 ounces per head per day. Now we have to take account of the fact that a part of the requirements of food-grains and pulses, in the case of non-vegetarians, is met by the consumption of meat and fish. It is practically impossible to ascertain the quantity of meat and fish consumed in British India during one year, and so, in the absence of any definite information, I think it best to make due allowance for them by adopting a standard of inquiry which may be less than the average standard calculated above. To make proper allowance for the consumption of meat and fish, if we assume that roughly one-half of the population, on an average, takes as much meat and or fish as to reduce their requirements of food-grains by one-eighth during one year, we will have to reduce the average standard by one-sixteenth. After careful consideration I have decided to adopt the following standard :—

Quantity of food-grains and pulses required in addition to vegetables and other articles per head per day.

Age	oz.
0 to 1	nil
1 to 2 (to the mother)	5
2 to 5	8
5 to 10	12
10 to 15	16
15 to 50 (males)	28
15 to 50 (females)	24
Above 50	20

The weighted average of the above standard, taking into consideration the population at various age-groups, comes to 19·5 ounces per head per day for the whole population. It will be seen that this quantity is 6·25 per cent. less than that calculated from the average standard, and I think that this reduction of one-sixteenth in the weighted average for the whole population may be taken to represent the consumption of meat and fish fairly well. In the above table I have also given the standard adopted by Rai Bahadur Ganga Ram, and from the above discussion it

would be quite apparent that he adopted as his standard an underestimate of the requirements.

Population of British India in 1911 according to age-groups.

After deciding the rations of food-grains and pulses we have to find out the population of British India at different age-groups. In Second Part of Volume I of the Census Report for 1911 the figures for different provinces are given and they are added up and given in the following table. After making a slight allowance for the population whose ages were not recorded in those returns we get the population of British India in 1911 according to age-groups as given in column 3 below:—

Age	Population as given in the Census Report	Population in 1911 (after making allowance for those whose ages were not recorded)
1	2	3
	Thousands	Millions
0 to 1	7,913	8·0
1 to 2	3,964	4·0
2 to 5	21,182	21·2
5 to 10	34,216	34·5
10 to 15	26,741	27·0
15 to 50 (males) ..	121,526	61·0
15 to 50 (females) ..		60·6
Above 50	27,426	28·0

Total quantity of food-grains required by the whole population of British India.

With the figures of population at different age-groups before us and the standard of food-grains finally decided upon, it is very easy to find out the total quantity of food-grains and pulses required by

the whole population of British India in 1911, and it is calculated in the following table :—

Age	Population in 1911 (in millions)	Quantity of food-grains required per head per day	Quantity of food-grains required by the whole population per day
1	2	3	4
		oz.	tons
0 to 1 ..	8·0	nil	nil
1 to 2 ..	4·0	5	558·0
2 to 5 ..	21·2	8	4,732·1
5 to 10 ..	34·5	12	11,551·3
10 to 15 ..	27·0	16	12,053·6
15 to 50 (males) ..	61·0	28	47,656·3
15 to 50 (females) ..	60·6	24	40,580·4
Above 50 ..	28·0	22	15,625·0
		Total quantity per day	132,756·7 tons
		Total quantity per annum ..	48·46 million tons

So we find that the total quantity required in 1911-12 amounted to 48·46 million tons. Now I proceed to estimate the quantity required during different years of the period. For this purpose it is necessary for us to know the estimated population of British India during these years. The method that is generally adopted for estimating the population in the intercensal period is very simple. It is based on the assumption that the same rate of increase holds good as in previous intercensal period. The annual rate of increase of population from previous census figures is estimated in the following way. If r represents the annual rate of increase per unit and P_1 the population at the last census and P the population at the census previous to the last one, then

$$P_1 = P\,(1+r)^{10}$$

If we know P and P_1 we can easily calculate the value of r from the above equation. The population of British India in 1891, 1901 and 1911 was as follows :—

	Millions
1891	221·2
1901	231·6
1911	244·3

The rate of increase during 1891—1901 is given by the equation

$$231{\cdot}6 \times 221{\cdot}2 \ (1+r)^{10}$$

whence $r = 0{\cdot}00463$ or 0·463 per cent. per annum. Similarly the annual rate of increase during 1901—1911 calculated in similar manner gives $r = 0{\cdot}00535$ or 0·535 per cent. per annum. Taking average of these two, we get 0·499 per cent. Therefore for estimating the population in intercensal period 1911—1920, I assume that the annual rate of compound increase of population was 0·5 per cent. If we further assume that the rate of increase of population in different age-groups was uniform and equal to that of the increase of population as a whole, 0·5 per cent. annual compound increase of population will cause a corresponding 0·5 per cent. annual compound increase in the quantity of food-grains required by the whole population. On the above basis, the quantity of food-grains and pulses required by the whole population of British India to maintain them in health and strength during different years works out as follows :—

	Millions of tons
1911-12	48·46
1912-13	48·70
1913-14	48·94
1914-15	49·18
1915-16	49·43
1916-17	49·68
1917-18	49·93

QUANTITY OF FOOD-GRAINS CONSUMED BY CATTLE.

The next step is to find out the total quantity of food-grains consumed by cattle. Rai Bahadur Ganga Ram has assumed the following quantity of cereals as given to one animal per day:—

Bulls and bullocks	All	@ 1 lb.
Cows	½ of total ..	,, 2 ,,
Cow-buffaloes	½ of total ..	,, 3 ,,
Horses and ponies	All	,, 3 ,,
Mules	All	,, 2 ,,

Although the quantity that is actually given by many cultivators to their bullocks is much greater than the average adopted by the Rai Bahadur, at any given time there must be a sufficiently large number of bulls and bullocks who must be getting no food-grains at all, and so I consider that the quantity of one pound per bullock per day represents a fairly good average. In the case of cows and cow-buffaloes, when they give milk they are generally given oil-cakes and cotton seeds in addition to food-grains and pulses, and so the average of two pounds and three pounds of food-grains and pulses, respectively, seems to be a somewhat high one. I consider that one pound and two pounds in the case of those cows and cow-buffaloes, respectively, who give milk, will represent a fair average, and if we err at all, it will be on the side of under-estimation. Horses and ponies do receive everywhere food-grains and pulses, and an average of three pounds per animal is in no case a high one. Mules generally do not get food-grains regularly, and so I have thought it necessary to make no definite allowance for them here. The standard that I wish to adopt finally stands as follows:—

Bulls and bullocks	All ..	@ 1 lb. per day
Cows	½ of total ..	,, 1 ,, ,, ,,
Cow-buffaloes	½ of total ..	,, 2 ,, ,, ,,
Horses and ponies	All	,, 3 ,, ,, ,,
Mules		nil

The number of these animals during different years is easily known from the "Agricultural Statistics of India" (Vol. I), and the amount of food-grains consumed by animals during 1911-12 is worked out in the following table :—

Kind of animal	Quantity of food-grains assumed to be given per day per animal, Rai Bahadur Ganga Ram's standard	Quantity of food-grains per day per animal (adopted for the inquiry)	Number of cattle	Quantity consumed by animals per day
	2	3	4	5
			Millions	Tons
Bulls and bullocks ..	All @ 1 lb.	All @ 1 lb.	46·6	20,803·6
Cows	½ „ 2 „	½ „ 1 „	36·7	8,191·9
Cow-buffaloes ..	½ „ 3 „	½ „ 2 „	13·6	6,071·4
Horses and ponies ..	All „ 3 „	All „ 3 „	1·9	2,544·6
Total quantity of food-grains consumed by animals per day ..	..	..	..	37,611·5
Total quantity of food-grains consumed by animals per annum	..	..	..	million tons 13·73

The quantity consumed by animals is similarly calculated for other years of the period from annual figures as given in the "Agricultural Statistics of India" (Vol. I), and it works out as follows :—

	Millions of tons
1911-12	13·73
1912-13	13·39
1913-14	13·69
1914-15	14·10
1915-16	14·23
1916-17	14·27
1917-18	14·19

But it must not be forgotten that in bad years when crops fail and the total supply of food-grains is less than the average, animals

also do not get as much food-grains as they do in ordinary years; and therefore the quantity of food-grains consumed by cattle during these years must be decreased to some extent. As I have taken a very low standard, I think it would be quite sufficient to decrease the quantity in the same proportion in which the total supply of food-grains falls short of the average supply. In the period under inquiry, as we shall see later on, the final supply falls short of the average in the following years to the following extent:—

1912–13	4·6 per cent. less
1913–14	11·8 ,, ,, ,,
1914–15	2·1 ,, ,, ,,

Therefore, decreasing the quantity consumed by animals in these years in the same proportion, we finally get the quantity of food-grains consumed by cattle as follows:—

	Millions of tons
1911–12	13·73
1912–13	12·77
1913–14	12·07
1914–15	13·80
1915–16	14·23
1916–17	14·27
1917–18	14·19

Quantity of food-grains required for seed.

To complete the first part of the inquiry, it is also necessary to ascertain the quantity of food-grains and pulses required for seed during the period under review. The standard adopted by Rai Bahadur Ganga Ram about the quantity of food-grains required for seed per acre compares favourably with that taken from Dr. Harold Mann's "Land and Labour in a Deccan Village" and Mr. N. G. Mukerjee's "Handbook of Indian Agriculture" the figures from which are given side by side in the table below; and so with a slight modification here and there I have decided to adopt the same standard. The figures for area under different crops in British India can be easily obtained from "Agricultural Statistics of

India" (Vol. I), and the total requirements for seed for 1911-12 are calculated in the following table :—

Kind of crop	Seed required per acre. R. B. Ganga Ram's standard	Seed required per acre. From Mr. N. G. Mukerjee's book	Seed required per acre. From Dr. H. Mann's book	Seed required per acre. The standard adopted for the inquiry	Cropped area in 1911-12	Seed required
1	2	3	4	5	6	7
	lb.	lb.	lb.	lb.	Millions of acres	Thousands of tons
Rice	24·7	20 to 30	..	24	76·64	821
Wheat	49·4	50	40 to 50	48	25·0	536
Barley	41·1	60	..	40	8·4	150
Juar	16·5	10 to 30	8	12	18·4	98
Bajra	4·1	6 to 10	5	4	13·1	23
Maize	18·5	..	..	20	5·6	50
Gram	16·5	15 to 50	32 to 40	32	14·13	202
Ragi	24·7	7 to 10	..	24	4·3	46
Other food-grains and pulses	..	..	16	16	29·5	211
TOTAL ..	..	..	..	..	..	2,137

The quantity required for seed for other years of the period is similarly calculated from cropped area of each year as given in "Agricultural Statistics," and it stands as follows :—

	Millions of tons
1911-12	2·14
1912-13	2·13
1913-14	2·02
1914-15	2·18
1915-16	2·17
1916-17	2·24
1917-18	2·28

TOTAL REQUIREMENTS OF FOOD-GRAINS AND PULSES.

Now by adding up the quantity of food-grains and pulses required by the whole population of British India to maintain them in health and strength and the quantities consumed by cattle and required for seed we are in a position to complete the first part of the

inquiry. The total requirements of the minimum quantity of food-grains and pulses stand as follows :—

(In millions of tons.)

Year	Quantity required for human consumption	Quantity consumed by cattle	Quantity required for seed	Total requirements
1	2	3	4	5
1911–12	48·46	13·73	2·14	64·33
1912–13	48·70	12·77	2·13	63·60
1913–14	48·94	12·07	2·02	63·03
1914–15	49·18	13·80	2·18	65·16
1915–16	49·43	14·23	2·17	65·83
1916–17	49·68	14·27	2·24	66·19
1917–18	49·93	14·19	2·28	66·40

TOTAL OUTTURN OF FOOD-GRAINS AND PULSES.

Now we enter on the second part of the inquiry to find out the total supply of food-grains for different years. In the " Estimates of Area and Yield of Principal Crops " annually published by the Director of Statistics, the yearly outturns of rice, wheat, barley, *juar*, *bajra*, maize and gram are given, and in the absence of any better estimates we may take these estimates as a fairly correct representation of the actual outturns of these crops. But on comparing the area under a certain crop for which the outturn figure is available in the " Estimates of Area and Yield," and the area under the same crop as given in the " Agricultural Statistics of India " (Volume I), we find that there is a slight difference in some and considerable difference in others. The difference is due to Native States being included in the outturn figures for some crops and the outturn figures for some parts of British India being not available in the case of other crops. Therefore I have calculated the average yield per acre in each year from the area and outturn figures as given in the " Estimates of Area and Yield of Principal Crops." By multiplying the average yield by the area under the crop as given in the " Agricultural Statistics of India " (Volume I), I have arrived at

the figures for the total outturn of the principal crops. The total outturns of rice, wheat, barley, *juar*, *bajra*, maize and gram are thus calculated for the year 1911-12 in a table below. But we are confronted with a serious difficulty in finding the total outturns of *ragi* and " other food-grains and pulses " the outturn figures for which are not available in the " Estimates of Area and Yield." The area under these crops can be known from the " Agricultural Statistics of India " (Vol. I), and the only alternative left about them is to find out the total standard normal outturn, by multiplying the area under the crop by the average normal yield per acre. Now the average normal yield per acre for *ragi* is given as 1,147 lb., and so its normal outturn can thus easily be calculated. But with the exception of *arhar*, the figures of average normal yield per acre in the case of " other food-grains and pulses " are not given in the " Agricultural Statistics of India " (Vol. I) ; neither do we exactly know what sorts of grains and pulses are included under " other food-grains and pulses " ; nor do we know the extent of area under each one of them. Under these circumstances I have thought it necessary to take an unweighted average of the average outturn per acre of all the remaining food-grains and pulses as given in Mr. Mukerjee's " Handbook of Indian Agriculture," as follows :—

	Average outturn per acre in pounds
Oats	1,600
Cheena (Millet)	600
Shyamma	400
Gondli	750
Kaon and Shyalanja	500
Kodo	600
Arhar (Pulse)	600
Kulthi	300
Popator Val	325
Gari Kalai (Soybean)	450
Khosari	300
Musuri	550
Bhringi	200
Kutki (Millet)	600
Urd (Pulse)	300
Mashkalai	450
Mung	350
Country peas	250
AVERAGE	507

And so I take 500 pounds as the average yield per acre in the case of other food-grains and pulses. The total outturn of food-grains and pulses has thus been calculated for 1911-12 in the following table :—

Kind of crop	Area under the crop * (1911–12)	Area for which outturn figures are available	Outturn from the "Estimates of Area and Yield"	Total outturn in 1911–12
1	2	3	4	5
	Millions of acres	Millions of acres	Millions of tons	Millions of tons
Rice	76·6	64·8	30·00	35·61
Wheat	25·0	31·1	9·90	7·96
Barley	8·4	2·7	0·97	3·02
Juar	18·4	13·2	2·47	3·44
Bajra	13·1	8·8	0·14	1·70
Maize	5·6	5·2	1·90	2·03
Gram	14·1	13·5	4·40	4·61
		Normal yield per acre		
Ragi	4·3	1147 lb.		2·20
Other food-grains and pulses	29·5	500 ,,		6·58
			TOTAL ..	67·15

* Taken from *Agricultural Statistics of British India*, Vol. I.

The total outturns of food-grains for other years of the period are similarly calculated from the figures as given in "Agricultural Statistics of India" and the "Estimates of Area and Yield", and they work out as follows :—

	Millions of tons
1911–12	67·15
1912–13	63·73
1913–14	58·18
1914–15	62·67
1915–16	66·78
1916–17	70 08
1917–18	68·89

THE WASTAGE OF FOOD-GRAINS.

But we have yet to make due allowance for wastage which takes place from the time of the final crop report to the time of actual consumption of the grain. Various are the items that can be

included under the term wastage. The following are the most significant ones :—

(*a*) Wastage due to crops getting rotten on the field, when the crop is ripe, by untimely rainfall and on the threshing floor by careless keeping ;

(*b*) Wastage due to defective methods of threshing.

(*c*) Wastage by pigs, jackals, dogs, poultry, birds and wild animals.

(*d*) Wastage by small insects (called *ghun* in Hindi) when the food-grains are stored.

(*e*) Wastage in transhipment.

(*f*) Wastage by rats and squirrels.

(*g*) Wastage due to the influence of time, *e.g.*, rice decreases in weight if kept for a long time, but improves in quality.

(*h*) Wastage in transforming the grain to the form suitable for human consumption, *e.g.*, removing the outer covering in the case of pulses.

(*i*) Wastage in grinding, sifting, winnowing and cleaning.

(*j*) Wastage in cooking and in general consumption.

(*k*) Wastage at the time of social functions, such as marriages, funerals, etc.

(*l*) Wastage due to unforeseen events, such as floods, fire, sinking of boats, etc.

The above list is already a long one and more items can easily be added. After a careful consideration I have come to the conclusion that any percentage of the total outturn which may be less than 10 would surely fall short of representing the actual wastage. Rai Bahadur Ganga Ram has also allowed 10 per cent. for wastage ; but I fail to understand why he has allowed it on the total human consumption only and not on the total outturn, because it is from the total outturn that wastage takes place. In the following table I have allowed 10 per cent. of the total outturn for wastage, and consequently the total outturn of food-grains and

pulses after deducting the wastage stands as given in column 4 below :—

Year	Total outturn (millions of tons)	Wastage 10 per cent. (millions of tons)	Total outturn after deducting the wastage (millions of tons)
1	2	3	4
1911–12	67·15	6·71	60·44
1912–13	63·73	6·37	57·36
1913–14	58·18	5·82	52·36
1914–15	62·67	6·27	56·40
1915–16	66·78	6·68	60·10
1916–17	70·08	7·01	63·07
1917–18	68·89	6·89	62·00

EXCESS OF IMPORTS OF FOOD-GRAINS FROM NATIVE STATES.

But the figures for total supply of food-grains will not be complete unless we add the excess of imports of food-grains from Native States and subtract the excess of exports of food-grains to foreign countries. "Inland Trade (Rail and River-borne) of India" gives statistics for exports and imports of food-grains from Kashmir, Rajputana, Central India, Hyderabad, and the Mysore State ; and from these figures the excess is calculated in the following table :—

Year	Imports of food-grains from Native States	Exports of food-grains to Native States	Excess	Excess in thousands of tons
1	2	3	4	5
	cwt.	cwt.	cwt.	
1911–12	9,207	4,093	5,114	256
1912–13	12,494	6,293	6,201	310
1913–14	11,336	5,791	5,545	277
1914–15	9,205	5,890	3,315	166
1915–16	11,189	6,425	4,764	238
1916–17	12,312	5,395	6,917	346
1917–18	10,370	4,247	6,123	306

Excess of exports of food-grains to foreign countries.

"The Review of the Trade of India" similarly gives figures for exports and imports of food-grains to and from foreign countries, and the excess of exports of food-grains is calculated in the following table :—

Year	Total exports of food-grains to foreign countries	Total imports of food-grains from foreign countries	Excess	Excess
	cwt.	cwt.	cwt.	Millions of tons
1911-12	102,400	191	102,209	5·11
1912-13	110,297	185	110,112	5·51
1913-14	83,895	370	83,525	4·18
1914-15	51,418	774	50,644	2·53
1915-16	48,719	1,143	47,576	2·38
1916-17	58,293	254	58,039	2·90
1917-18	90,274	88	90,186	4·51

Total supply of food-grains and pulses.

The figures for the total supply of food-grains and pulses in British India finally stand as follows :—

(In millions of tons.)

Year	Total outturn excluding wastage	Excess of imports of food-grains from Native States	Excess of exports of food-grains to foreign countries	Total supply
1911-12	60·44	0·26	5·11	55·59
1912-13	57·36	0·31	5·51	52·16
1913-14	52·36	0·28	4·18	48·46
1914-15	56·40	0·17	2·53	54·04
1915-16	60·10	0·24	2·38	57·96
1916-17	63·07	0·35	2·90	60·52
1917-18	62·00	0·31	4·51	57·80

(To be concluded.)

TOXIC ROOT-INTERFERENCE IN PLANTS.*

THE earlier investigations of the late Mr. Spencer Pickering at the Woburn Experimental Fruit Farm on the action of grass on fruit trees, which were described in the third (1903) and thirteenth (1911) reports issued from that station, sufficed to show that, in spite of some variability in degree, there is a definite deleterious effect on the health and development of fruit trees caused by grass grown immediately around them. That this is a general result and not a matter of special soil or other local conditions at Woburn has been demonstrated by independent experiments conducted in this country at Long Ashton, Wisley, and other places. So marked is the crippling effect of the grass in some cases that death of the trees has resulted. On the other hand, the presence of numerous grass orchards in apparently healthy and vigorous condition in many parts of the country made the existence of any direct toxic action on the part of the grass, such as Mr. Pickering was led to postulate, appear doubtful. It was evident that the action, if any, must be relatively complex, and the later work at Woburn now shows that this is so. In the seventeenth (1920) annual report from that centre new evidence is recorded which indicates not only direct toxicity of grass on fruit trees, but also a similar effect for any one plant on another when the two are grown in close association.

It is therein claimed that the action of grass is shown to be due to toxic substances derived from the grass, and is not the indirect result of any adverse effect on soil conditions as regards aeration, available moisture, or plant food. In a series of experiments in which apple trees were grown in pots and the grass in shallow, perforated trays resting on the soil of the pots, the injurious effect was secured, notwithstanding that the grass roots, by being confined

* Reprinted from *Nature*, Vol. 106, No. 2673.

to the soil in the tray, could neither impoverish the soil in the pot below, nor deprive it of oxygen or water. A similar result was obtained when the grass was grown in sand, instead of soil, in the perforated trays. The presence of grass roots in the soil in which the tree was growing was thus immaterial for the manifestation of the dwarfing effect, and it follows that nothing which might be abstracted from the soil by them could be held accountable for the results. The converse view that grass added to the soil something deleterious to the tree appears to offer the only explanation, the toxic material presumably being conveyed from the trays to the soil in the pots by means of the drainage water from the former. Direct evidence was secured on this point by utilizing for watering the trees the leachings from the grass trays, the trays in this case not resting on the soil of the pots but being placed elsewhere. The injurious effect on the tree was as marked as before. When, however, the leachings were allowed to stand for twenty-four hours exposed to the air before being used for watering the pots, the trees apparently were unaffected.

It was considered by Mr. Pickering that these experiments prove that the leachings contain an oxidizable substance derived from the roots of the grass which in its unoxidized form is detrimental to the growth of the trees, but after oxidation is no longer of a toxic character. The suggestion that it is nothing more than carbon dioxide given off by the grass roots was, according to him, disproved by the results of a series of experiments in which the plants were grown in pots as above, "with or without a surface crop in the trays, watering them in one case with ordinary water, in another case with a saturated solution of carbon dioxide, and in a third case with clear lime water, which, since lime absorbs carbon dioxide, would presumably have the reverse effect of the carbon dioxide water." They were of a purely negative character, and in no way indicated that the toxic action of the surface crop was modified by the differential treatment. Also bearing on this point are observations direct and indirect, in several of the numerous series of experiments made which tend to show that the toxin after "oxidation" actually serves as a nutrient to plants exposed to its action. As to the

nature of this substance and the manner in which it is communicated by the roots to the soil, no positive views are put forward, but Mr. Pickering held that there was no reason to assume that it is excreted by the roots, and he was inclined to attribute its origin to the debris which roots furnish to the medium in which they grow.

The later phases of Mr. Pickering's investigations were mainly directed towards proving that the grass injury to fruit trees is only a particular case of the action of one growing crop on another. By means of experiments on lines similar to those already reviewed, he showed for a wide variety of plants a corresponding toxic effect, and, moreover, demonstrated that the action is reciprocal. It is not confined to plants of a different kind ; it is at least equally marked when the associated plants are similar. Further, it follows that the individual plant tends to restrict its own growth through the toxin which it produces so long as that remains " unoxidized " in the immediate range of the root system.

A new light is thus thrown on the question of soil drainage, it being evident that soil conditions facilitating rapid removal of the toxin or its oxidation must tend to promote healthier growth, provided that food supplies do not escape. Differences in efficiency of drainage may accordingly be held to account for the divergences of grass effect on trees which have been recorded in various localities.

With every plant exerting a direct toxic effect on all others within its range, the phenomena of root-interference do not merely represent the outcome of competition for food supplies. Mr. Pickering gave particular attention to the aspect of the case where similar plants are grown massed together, and his observations are interesting not only in themselves, but also because of considerations raised by them of economic significance as applied to agricultural and horticultural crops. He found that where the mass of soil available is below a certain limit, the total amount of plant growth produced is independent of the number of plants present. This holds whether the individual plants are grown with their roots in separate compartments of the soil-containing receptacle so that root-interference is

eliminated, or in a similar-sized vessel, without divisions which permits unrestricted root-interference ; but it applies only to cases where the plants are of the same age. When some are younger than others, the latter grow more vigorously at the expense of the former in the undivided containers, but the total combined growth falls considerably short of the amount which the mass of soil is capable of producing with plants of equal age. The latter point is, however, reached when plants of unequal age are grown in the divided vessels with no root-interference. In such cases the toxic action of the older plant on the younger was thus definitely illustrated where root-interference was possible and the available growth standard was not nearly reached, indicating that the plants were prevented from utilizing all the nutrient present.

The question of range of root-interference has become latterly of considerably increased importance in fruit culture. The present high cost of labour has driven fruit-growers to consider how to reduce the expenses of cultivation of their orchards and plantations. In some cases this has been attempted by grassing them down, but the trees generally suffer so severely that this method can be practised successfully only where local conditions minimize grass influence. Cover cropping, followed by the ploughing in of the cover crop to serve as green manure, is also receiving attention, particularly on account of the increasing difficulty of obtaining adequate supplies of farmyard and stable manure. Where the trees are grown on strong and relatively deep-rooting types of root-stocks, such as the stronger free stocks for apples, the toxic effect of the cover crop or grass may be relatively negligible, provided that the soil is deep and well-drained. With superficial rooting types of root-stock, such as the Paradise or dwarfing stocks for apples, however, the toxic influence of the surface crop will certainly be more strongly marked, and may be sufficiently pronounced to render grassing or cover cropping other than for periods of short duration not only dangerous in many cases, but entirely impracticable in some. The use of the latter forms of root-stock is accordingly open to objection on this score, and, in so far as the grower may be debarred from these alternatives in the treatment of his plantation, and confined to clean cultivation,

the modern English policy of advocacy of dwarfing stocks may perhaps prove to be misguided.

The recent announcement of the closing down of the Woburn Experimental Fruit Farm, followed so closely by that of the regretted death of its distinguished director, marks the end of the most important systematic attempt to grapple with the problems of fruit culture since the days of Thomas Andrew Knight. Hotly disputed as some of the conclusions reached there have been, the general value of its contributions to pomological science stands, nevertheless, beyond question. Although further development of the subject in this country must now be left to other stations, the influence of Woburn will persist, and future investigators will find their work materially simplified not only by the constructive results achieved there, but also by the illustrations afforded of the pitfalls to which field experiments in pomology are liable.

B. T. P. B.

Notes

CONSTITUTION OF A CENTRAL COTTON COMMITTEE.

THE following Resolution (No. 404-22), dated the 31st March, 1921, has been issued by the Government of India in the Department of Revenue and Agriculture :—

In their Resolution No. 674-191, dated the 2nd August, 1919, the Government of India indicated broadly the lines on which it was proposed to dispose of the recommendations in the Report of the Indian Cotton Committee. They are now able to announce their decision on the proposals made in Chapter XIX of the Report relating to the formation of a Central Cotton Committee.

2. Local Governments and Administrations were consulted and were asked to obtain the views of the various Trade Associations and Chambers of Commerce on the proposal. Replies have now been received from all local Governments and Administrations, who generally support the proposal, and the Government of India have accordingly decided to constitute a Central Cotton Committee with headquarters at Bombay.

3. The functions of the Committee will be mainly advisory, and, subject to any modifications and additions which may subsequently be found necessary, will follow generally the lines indicated by the Indian Cotton Committee in paragraph 261 of its Report.

4. The Committee will, at the outset, be composed as follows, but additions to, and alterations in, its composition may be made from time to time on the recommendation of the Committee :

Official Representatives.

President.

1. The Agricultural Adviser to the Government of India.

Members.

A representative of the Agricultural Department in—

2. Madras.
3. Bombay.
4. The Punjab.
5. The United Provinces.
6. Burma.
7. The Central Provinces and Berar.
8. Sind.
9. The Director General of Commercial Intelligence.

Non-official Representatives.

A representative of each of the following bodies:—

10. The East India Cotton Association, if established, or, in the alternative, the Bombay Cotton Trade Association.
11. The Bombay Millowners' Association.
12. The Bombay Chamber of Commerce.
13. The Ahmedabad Millowners' Association.
14. The Karachi Chamber of Commerce.
15. The Tuticorin Chamber of Commerce.
16. The Upper India Chamber of Commerce.

17 and 18. Two representatives of the Central Provinces and Berar to be nominated by the local Administration from manufacturers or ginners.

19. A representative of the Madras Presidency to be nominated by the local Government from manufacturers or ginners.
20. A representative of the Punjab to be nominated by the local Government from manufacturers, ginners or large producers.

21. A representative of Bengal.
22. A representative of Lancashire.

OTHER REPRESENTATIVES.

23. A member of the Co-operative Department, official or non-official, to be nominated by the Government of India.
24. A representative of the Hyderabad State.
25. A representative of the Baroda State.
26. A joint representative of the States in Rajputana and Central India.

5. The members of the Committee will be appointed in the first instance for a period of two years, and steps will now be taken to nominate the *personnel* in consultation with the local Governments and Administrations and the Darbars concerned. Proposals have been approved by His Majesty's Secretary of State regarding the appointment of a Secretary to the Committee, and the officer selected for this appointment is Mr. B. C. Burt, at present a Deputy Director of Agriculture in the United Provinces. On his appointment the Secretary will be directed to submit proposals regarding his staff and the place and time of the first meeting of the Committee.

6. The cost of the Committee will be met from Imperial Revenues.

7. Subject to the submission to them for sanction of any proposals requiring it under the ordinary financial rules, the Government of India leave it to the discretion of local Governments and Administrations to decide the composition and details of organization of their provincial and local committees.

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CATTLE SALE AND DEMONSTRATION AT PUSA.

THE usual half-yearly sale of Montgomery and Ayrshire-Montgomery stock from the Pusa pedigree herds was held on Thursday, the 10th March, 1921, at Pusa. Twenty-nine animals came under the hammer, comprising 1 Montgomery bull, 15

THE "SELF-BINDERS" WORKING IN A LIGHT CROP OF OATS.

Montgomery cows, 9 young Montgomery bulls and 4 Ayrshire-Montgomery bullocks. Bidding was very brisk and the 25 animals sold realized Rs. 4,765.

The average prices made were Rs. 232 for cows, Rs. 164 for young bulls, and Rs. 108 for bullocks.

These sales are now attracting considerable attention and the animals are sold to all parts of India, while the prices made show that there is an ever-increasing demand for good class milch stock of reliable pedigree. Several cows this year were sold with calf at foot, and the competition for these was very keen.

Prior to the sale, a demonstration of tractor-driven implements was given on the arable area at which tractors were shown working various types of agricultural machinery, and the greatest interest was taken in their performances by those attending the sale.

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TRIALS WITH SELF-BINDERS AT PUSA.

Two "self-binders" were imported from England and arrived in time to be used during the present harvest. They are both of six feet cut, and the draft is an easy one for a moderate-powered tractor.

The fields at Pusa are large enough to provide a good long run and are well suited for binder work.

During the trials, both machines dealt satisfactorily with badly laid oats, and cut both light and good crops equally well (Plates XX and XXI).

It is too early yet to give figures, but the saving of labour is enormous, and this at a time of the year when it is most valuable. Ten to twelve acres per day per machine seem to be quite easily attained, but the time was too short to make anything like a complete test of the capabilities of output.

So far as the writer is aware, this is the first case of binders being successfully used in India. It is, of course, only since the employment of agricultural tractors that there has really been an opportunity of usefully employing such implements. Before the days of tractors, the draft was much too heavy for Indian cattle,

and the opportunities for the employment of horses were practically nil. Over the large wheat-growing districts of North-west India, the advent of power-harvesting machinery opens up large and new prospects. This is specially the case where harvesting clashes with sowing of the *kharif* crops. If by the employment of binders and power-threshing machines harvesting can be completed in a reasonable time, it will enormously facilitate agricultural work, especially on canal areas where double-cropping is a common practice. [G. S. HENDERSON.]

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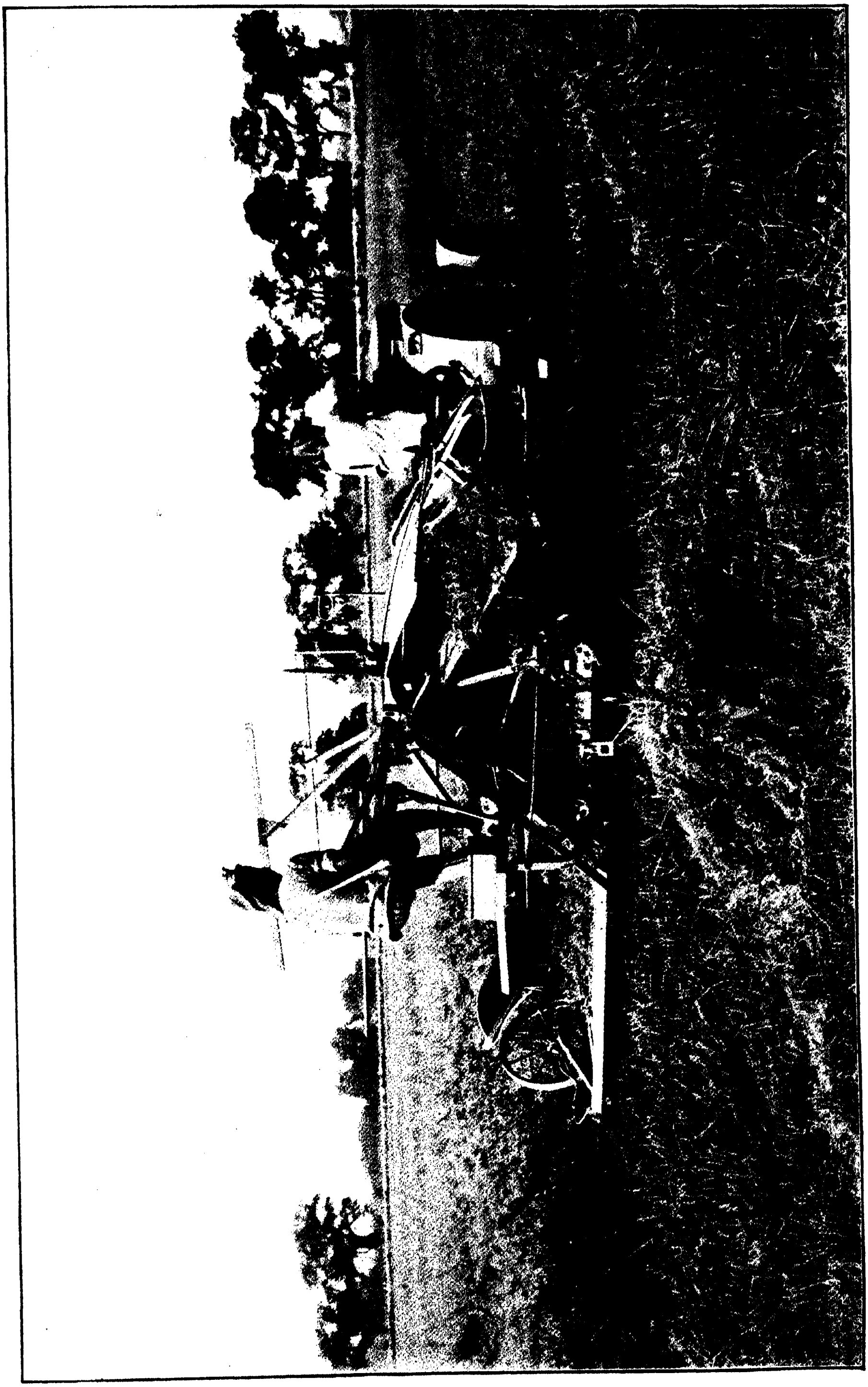
COMPARATIVE COSTS OF JAVA AND INDIAN SUGAR.

IN the "International Sugar Journal" for February 1921, Dr. Prinsen Geerligs figures the present net cost price of white Java sugar ready for direct consumption at 10·67 guilders per picul, or £14-9-0 per long ton, all included, save interest on capital and renewals. The cost of refining crystals is about one pound lower per long ton. The excess profits tax, which is levied on the difference between the selling price and 10 guilders per picul, is not incorporated in this price. It is estimated for 1920 at 5 guilders per picul, thus bringing the total net cost price, inclusive of all taxes, but excluding interest on capital and renewals, to 15·67 guilders per picul, or £ 21-4-5 per ton of white sugar. Taking interest and renewals into account, the cost in Java would come to £ 23 per ton, equal to 17*s.* per maund (80 lb.). If we add to it a moderate profit of 10 per cent. on the capital outlay, the price per maund will come to 18*s.* 8*d.*

Taking present exchange as 1*s.* 4*d.* to the rupee, we get Rs. 14 as the cost price per maund, all included, at warehouse in Java. Adding to this ocean freight and other charges incidental to shipping and landing, we get a figure of nearly Rs. 16 per maund landed at Calcutta. India now levies a 15 per cent. *ad valorem* duty, pitched at Rs. 32-4 per cwt. on 23 Dutch standard and Rs. 29-12 on 15 Dutch standard and under, thus adding Rs. 3-8 in the first case and Rs. 3-3 in the second. This raises the price to Rs. 19-8-0 per

PLATE XXI.



THE "SELF-BINDERS" WORKING IN A HEAVY CROP OF OATS.

maund in the case of white sugar for direct consumption and to a little less than Rs. 19 in the case of low grade sugar.

We thus get a basis of Rs. 20 per maund before Java sugar can come into competition with Indian sugar at sugar consumption centres up-country. Now, at a basis of Rs. 20 per maund, we get a value of 11 annas per maund for cane, which can be paid by all factories doing 7 per cent. on cane, which is a fair efficiency to demand. It will thus be seen that the future for Indian sugar is very favourable, and it is to be hoped that full advantage will be taken of present conditions. [WYNNE SAYER.]

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GERMAN PRODUCTION OF BEET SUGAR DURING 1920-21.

ACCORDING to the "American Sugar Bulletin," dated January 29, 1921, reports in the "Deutsche Zuckerindustrie" of December 17, 1920, indicate that the German crop will bear out recent reports of heavy yields and consequent production in excess of early estimates. According to these reports, the crop will be about 1,200,000 tons which will not only provide an increased ration for household consumption, but will permit of distribution to all industries, many of which were cut off during the last year and under the first regulations this year were directed to secure their sugar from outside the German Empire.

It is even possible that at a satisfactory price a small export may be possible, after provision has been made for domestic needs and the prospects of the next crop are more fully known. The Government has announced that it intends to increase the internal tax on sugar to 100 marks per 100 kilograms. The present tax is 7 pfennig per pound.

The effect of such a heavy increase in taxation in normal times would have been a decrease in consumption and a possible curtailment of area planted. But with the mark at its present value, this tax is likely to favour export of sugar from Germany, as in comparison with the world value of sugar, the tax is nominal on the prices made by exported sugar. As, however, Germany's present production is nowhere near her internal consumption, there is little probability of much export anywhere. [WYNNE SAYER.]

U. S. BEET SUGAR CROP FOR THE SEASON 1920-21.

"The United States Monthly Crop Reporter," for December 1920, contains a detailed estimate of the United States beet sugar crop for 1920-21 amounting to 990,710 long tons which is the largest crop yet produced in that country.

The crop during the last five years was as under :—

Year		Long tons
1915-16	...	780,550
1916-17	...	732,700
1917-18	...	683,000
1918-19	...	674,900
1919-20	...	653,000

If the weather conditions continued as favourable as at the time this estimate was made (1st December, 1920), there is every reason to suppose that the actual figures will not be far out.

It will thus be seen that, as compared with last year, the United States of America should have 337,710 long tons more home-grown sugar, and, as she is a large importer, this reduction in her requirements of foreign sugar may have some influence on the prices of this commodity in the world's markets. [Wynne Sayer.]

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FRENCH BEET SUGAR CROP FOR THE SEASON 1920-21.

It is estimated that the production of sugar in France during the season 1920-21 will amount to 326,238 long tons of raw sugar against 169,560 tons for the last campaign. These figures indicate that the French production will be 293,600 tons of refined sugar. It should be remembered that the pre-war annual consumption of sugar in France was 650,000 tons, and, in spite of this 92 per cent. increase in production, France will still have to import sugar from other countries, if no rationing is resorted to. [Wynne Sayer.]

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MECHANICAL COTTON PICKERS.

There have been many attempts to invent a mechanical cotton picker, but with little success. The "Textile Recorder" of Manchester, however, describes in a recent issue an invention of

Mr. Louis Carrol Stukenborg, an American, who has carried out a number of experiments on a cotton plantation at Scima, Alabama. The mechanism consists of a picker-head which is directed by hand to the cotton boll. In this head are two cylindrical brushes (revolving inwardly) and a take-off device which combs the cotton from the brushes as they gather it from the plant. Attached to the picker-head is a flexible tube through which the cotton is conveyed by suction, and the cotton then passes into a patented cleaning device from which it falls into a receptacle prepared to receive it.

The mechanism in the picker-head is operated by means of a jointed flexible shaft leading from the engine, and it is stated that the head is counterbalanced so that there is no weight in the hand when cotton is being picked. The invention can be attached to any kind of type of power machinery. A small tractor, for instance, is very convenient, and as many picker-heads may be used as desired, but each requires a man to direct it, and as more picker-heads are used more power will be required. A small garden tractor capable of doing the work of one horse can, it is claimed, operate two or more picker-heads. To a large tractor there may be many heads attached. An automobile or other power machinery may also be employed to operate the machine.

It is claimed for this cotton-picker that it has a capacity on an average, through the cotton season, of about five to one as compared with hand labour, this depending largely upon the skill of hand labour and of the men operating the cotton-picking machine. But it is further urged that it does the work better than it can be done by hand, picking the cotton from the boll cleaner, better and more rapidly, and preparing it perfectly for ginning. As to the actual work of the picker-head, it is said :—It does not injure the fibre as is done by hand picking, neither is the fibre twisted, matted, squeezed and rolled up like snowballs. Instead, each seed of each lock is completely segregated in a feathery, fluffy condition, no tangles or bunches of cotton to interfere with the ginning process. The lint on each seed is more or less cleaned, straightened and laid parallel. This gives the cotton an opportunity to dry properly, although the

cotton in passing through the machine is relieved of its dampness to a very great extent.

The "Canadian Textile Journal" describes what it calls "the first successful cotton-picking machine" being demonstrated on a farm near Dallas, Texas, as under :—The machine consists of a high gasoline tractor with cotton-picking machinery inside. The machinery consists of two vertical cylinders on each side, containing needles or fingers that revolve, each on its axis, wrapping the lint about them, the contact being made by sawlike teeth. The cylinders revolve in a direction opposite to the direction the machine is going, with the effect of presenting to every part of the cotton plant a needle with a serrated edge that engages the lint and wraps it about the needle, but with no other motion. There are more than 600 of these needles in the four cylinders. The cotton is stripped from the needles and carried on an endless belt through a blowing compartment, where dust and leaves are eliminated, into a pair of sacks at the rear of the machine. On an exhibition round, the machine crossed the field and came back, picking one row of cotton each way and taking eight minutes for the round. The gathered cotton weighed sixty-seven pounds. It is claimed that the capacity of the machine is from 500 to 600 pounds of seed cotton. [*The Indian Textile Journal*, Vol. XXXI, No. 363, December 1920.]

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NEW EGYPTIAN COTTON LAW.

THE following Law prescribing measures to prevent the mixing of different varieties of unginned cotton and cotton seeds has been issued by the Egyptian Government :—

Art. 1. For the purposes of the present law, the expression "variety of cotton" will be understood to comprise the varieties of cotton specified in the annexure to the present law as well as any varieties which may be added to this annexure by rulings of our Minister of Agriculture.

Art. 2. It is prohibited—

(1) to mix or cause to be mixed any one variety of cotton with cotton of any other variety or varieties ;

(2) to mix or cause to be mixed the seed of any one variety of cotton with that of any other or all other varieties of cotton.

Art. 3. This prohibition applies—

(*a*) To all varieties of cotton between the periods of harvesting and ginning.

(*b*) To the seeds of all varieties. At the same time seeds destined for exportation, for pressing or for any other industrial use are excepted from this prohibition, but only on the condition that the alleged purpose can be clearly established.

(*c*) To any person in whose possession or under whose control unginned cotton or cotton seed may be found for whatever purpose.

Art. 4. It is forbidden, in the absence of a special authorization to be issued by the Minister of Agriculture, to despatch cotton seeds from any port of the Egyptian territory towards the interior of the country.

Art. 5. Any person, who, having unginned cotton or cotton seeds in his possession or under his control, omits to take necessary precautions to prevent the mixing

(*a*) of one variety of this cotton with the cotton of any other variety or varieties,

(*b*) of the seed of one variety of cotton with the seed of any other or all other varieties of cotton,

is liable to the punishment provided by Art. 9 of the present law.

Art. 6. Rules regulating the conditions of application of the present law will be issued by the Minister of Agriculture with the approval of the Council of Ministers.

Art. 7. The Omdehs and Sheikhs will be entrusted with the execution of the provisions of the present law as well as of the rules hereinbefore mentioned, with the assistance of the Gaffirs and under surveillance of the Moudirs and the Mamours-markez, the Inspectors, Sub-inspectors and Moawens of the Ministry of Agriculture as well as all other agents designated for this purpose.

Art. 8. Infringements of the provisions of the present law and of the rules hereinbefore mentioned may be certified by any officer of the judicial police or by any agent of the Ministry of Agriculture designated for this purpose. They may, in consequence, visit all fields, all public or private depôts and all ginning factories, in order to satisfy themselves that the provisions of the present law or by the orders hereinbefore mentioned are observed and adhered to.

These visits may not be extended to cover localities exclusively destined for habitation.

Art. 9. All infringements against the provisions of this present law and of the rules hereinbefore mentioned will be punished by imprisonment not exceeding a week and by a fine not exceeding P. T. 100 or by one of these two penalties only. Cotton and cotton seed, the object of the contravention, will be seized and confiscated to the profit of the State as far as 5 per cent. of their value is concerned. Seed obtained from the balance will be, in all cases, destined for exportation or for pressing.

Art. 10. When a prosecution has been instituted simultaneously against strangers and local residents for the same contravention the mixed Court will be competent to try all the culprits.

Art. 11. Our Ministers of Interior, of Justice, and of Agriculture are charged, each in his own capacity, with the execution of the present law, which will come into force from the date of its publication in the Official Journal.

Annexure to the Law. Sakellaridis, Pilion, Mit Afifi, Nubari, Assili, Abbassi, Casulli, Voltos, Theodorou, Fathi, Aschmount, Zagora, Yoannovitch, Makssussi.

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IMPORTATION OF COTTON SEED, RAW COTTON, MAIZE AND BARLEY INTO SOUTH AFRICA.

The following two notices, issued by the Secretary for Agriculture, Union of South Africa, are republished for information :—

Cotton seed and raw cotton. The Department of Agriculture again directs attention to the provision in the Agricultural Pests Act,

No. 11 of 1911, requiring that a special permit be obtained to import any cotton seed into the Union from oversea or from other than British territory in South Africa. It has been decided that permits shall be given only in respect of seed intended for sowing, and then only when the introduction of such seed is deemed desirable by the Chief of the Cotton Division. Each application for a permit should state the name of the variety, the country of origin, the quantity desired, the port through which it would arrive, and the full name and address of both the proposed consignor and consignee. Cotton seed that is allowed to enter will be fumigated with carbon bisulphide, and the consignee required to pay a fee of 6*d.* per 100 lb. of seed for such treatment.

A proposition to restrict the importation of raw cotton is under consideration. Raw (unmanufactured) cotton almost unavoidably contains some cotton seeds, and there is danger of introducing a very serious pest of growing cotton in such seed. The public is therefore cautioned to avoid making any arrangements to import raw cotton without consulting the Department of Agriculture. Raw cotton is sometimes used as packing material for merchandise. Importers who receive furniture or any other goods packed with such cotton should warn the shipper to discontinue the practice.

Maize and barley. Attention is directed to the provisions of Proclamation No. 33, 1920, requiring that a special permit be obtained to import the grain of maize and barley into the Union.

It has been decided that permits shall be given only in respect of small quantities of seed intended for sowing and then only when the introduction of such seed is deemed desirable, and will be grown under conditions approved of by the Chief of the Division of Botany.

Each application for a permit should be addressed to the Chief, Division of Entomology, Box 513, Pretoria, and should state the name of the variety, the country of origin, the quantity desired, the port through which it would arrive, and the full name and address of both the proposed consignor and consignee.

THE SELECTION OF FOOD PLANTS BY INSECTS.

In the "American Naturalist" for July-August 1920, Dr. Charles T. Brues, of the Bussey Institution of Harvard University, gives an account of his study of the selection of food plants by insects, with special reference to Lepidoptera larvæ. Dr. Brues finds that the lepidopterous insects show a very fixed instinct to select definite plants for larval food and that many are extremely precise in this respect, although some are less so, and others are quite catholic in their tastes. Furthermore, there is much to show the existence of a so-called "botanical instinct" in species, genera and even families, whereby evidently related plants and these only serve as food. A few species have departed from the general habit so far that they have become carnivorous.

To avoid numerous difficulties it seems clear to Dr. Brues that the selection of food-plants by the lepidopterous insects studied by him must be considered as dependent upon one or several of a number of factors. Among these he includes the following :—

1. The odour of the plant and also its taste, which is no doubt closely connected with odour. Associations reasonably placed in this category would be the oligophagous species occurring, for example, on various Cruciferæ, various Umbelliferæ, and various Compositæ. An additional argument for the importance of this factor is seen in the less common utilization by the same insect of several plants in a family like the Solanaceæ where a more or less similar odour does not become a family characteristic.

2. Some attribute of the plant, perhaps an odour, but far less pronounced to our own senses than those mentioned above. Species restricted to plants like Leguminosæ or Violaceæ may be considered in this category. Undoubtedly, there is some attribute of such plants which insects can recognize in a general way and not as a specific characteristic of some single plant species or genus. The "botanical instinct" of some caterpillars that has frequently been commented upon would appear to be an exaggerated power of recognition of this sort.

3. A similarity in the immediate environment or general form of the food-plant. The effect of something of this sort is seen particularly in oligophagous and also polyphagous caterpillars feeding mainly on trees or shrubs, such as the gipsy-moth, Cecropia moth, etc., and those of certain species like some of the Arctiid moths that feed upon a great variety of low plants.

4. Apparently chance associations that have become fixed, whereby diverse plants are utilized by oligophagous species. Secondarily polyphagous species show these in an exaggerated form. On account of their comparatively rare occurrence these seem to be analogous to stuctural mutations although they appear to be strictly modifications of instinct. These associations are much more apt to occur in some groups (families and general) than in others. [*Scientific American Monthly*, Vol. III, No. 1.]

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INCREASING THE PROTEIN CONTENT OF WHEAT.

Professor W. F. Gericke, of the University of California, presents, in "Science" for November 5th, 1920, the results of investigations on methods of increasing the protein content of wheat.

Wheats of the Pacific Coast States are conspicuously low in protein, so much so that western millers are obliged to ship in large quantities of high protein wheat to mix with their domestic wheats in order to manufacture flour of good baking qualities. The cause of the low protein content of western wheats has been the object of considerable investigation on the part of interested agronomists and plant physiologists for the last two decades. Results obtained from these investigations have led to a rather common belief that the cause of the low protein content of Pacific Coast wheat is primarily attributable to peculiar influences of climate.

Professor Gericke's investigations show that this belief is not correct, but that the protein yield is correlated with the application of certain forms of soluble nitrogen at different growth periods.

The data collected show a decided increase (about 77 per cent.) in the protein content of wheat obtained from the plants that received

nitrogen when they were 110 days old over those that were treated with nitrate at the time of planting. The protein content of the wheat obtained from these two different treatments are respectively 15·2 per cent. and 8·6 per cent. The data show that for each of the different applications of nitrate made after the time of planting, there was a corresponding increase in the protein content of wheat. As these increases in the protein content of wheat correspond with the length of the period of the different deferred applications of nitrate made after planting, this would indicate a significant relation between the state of development of the plant and the time when nitrate can be most effectively utilized by the plant in the production of high protein wheat. This emphasizes that the physiological status of the plant, as indicated in its different growth phases, is a factor of great importance in the utilization of plant food available to it.

Not only was the protein content of the wheat increased by all of the deferred applications of nitrogen, but the yield of produce, excepting that obtained by the latest application, was much larger from the plants that received nitrogen for the period of 33 to 72 days after planting than those that received nitrogen during the early growing period. The best quality wheat as determined by commercial grading was secured from the plants that received nitrogen 72 and 110 days after planting. This means that the high protein wheat berry was likewise plump and well filled.

Professor Gericke concludes that the results obtained in this investigation show that the low protein content of Pacific Coast States wheats is not due primarily to the climate as such, but to insufficiency of available nitrogen at certain growth periods of the plants. The climate is not without effect upon the availability of the plant food in the soil is obvious, but the emphasis to be laid on the climatic complex is that it affects the nutrition of the plant. This can be both in the kind and quantity of each of the different nutrients that may be available to it. That this availability is an important factor in affecting the composition of plant products is shown by the results of this investigation. [*Scientific American Monthly*, Vol. III, No. 1.]

CHEMICAL AND BACTERIOLOGICAL TESTS OF EGGS.

An exhaustive investigation of the chemical and bacteriological differences between fresh eggs and ordinary commercial eggs has been made by the U. S. Department of Agriculture, and has attracted attention not only in this country but abroad. The term fresh is properly applied to eggs only when they are less than twenty-four hours old and have been kept in a cool and well-aired place ever since laid. Other eggs are divided into those which have been taken from a sitting hen and those which have not. The tests of these two classes of eggs yielded the following results :—

1. The eggs gathered in July and August contain very few micro-organisms, and in many cases no coli bacteria were present whatever.

2. The majority of the tests of eggs of the first class when the shells were clean had comparatively few bacteria, and only 8·3 per cent. of these possessed more than 1,000,000 germs in one gram by volume.

3. Eggs with dirty shells, or with cracks, or eggs with a yolk which mingled with the albumen contained over 1,000,000 germs per gram by volume, but likewise 16·6 per cent. or 18·8 per cent. or 20 per cent. of them, respectively, were notably freer from coli bacteria than the first group.

4. Eggs having a speck of blood contained comparatively few bacteria ; those having a large spot of blood were usually richer in bacteria than those with a small spot : the majority contained fewer than ten coli bacteria per gram of the volume of the egg.

5. The determination of ammonia nitrogen contents showed that the decomposition of the albumen was greater in the different kinds of commercial eggs than in the fresh eggs ; but it was less than that of many eggs sold at retail. However, although a cracked or dirty shell indicated danger of infection and consequently decomposition, the tests showed that such eggs have as good keeping quality as those of the first class with clean shells, and that those collected in August and July are the best in this respect.

6. The eggs gathered in July and August and eggs of the first class with cracked or dirty shells can be employed without hesitation both in the household and the bakery.

7. Those eggs which were infected with bacteria included most of those in which the yolk had run into the white, and most of those in which the yolk showed a tendency to cling to the shell, as also all of those which were either partly or wholly musty or moldy, and all of those in which the yolk stuck fast to the shell, as likewise those in which the albumen was greenish in colour.

8. All the eggs with yolks which exhibited a slight tendency to stick to the shell were less defective from the chemical point of view than the cooking egg of the first class, while the musty eggs, those with intermingled whites and yolks, with greenish whites, and those with yolks which stuck tightly to the shell, usually exhibit a much greater degree of decomposition. The eggs with black spots contained five times as much ammonia nitrogen as the eggs in the previous groups. None of these eggs is fit for use either in the kitchen or in the bakery, with the exception of those in which the yolks stick but slightly to the shell. [*Scientific American Monthly*, Vol. III, No. 1.]

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SWEET POTATOES AS STOCK FOOD.

Sweet potato silage is a comparatively new contribution to an already variable ration for live stock in the South, a series of experiments covering a period of years as conducted by the agricultural experiment station of the University of Florida determining its fitness as a stock food. As a major crop in the Southern States, equalling in value that of the upland cotton acreage in Florida, its use in sustaining cattle during the winter months enhances its appreciation as a farm product.

Sweet potatoes, diverted from the storage house to the silo, are run through the ensilage cutter in the same fashion as corn or other products converted into silage. The storage facilities as now in vogue involve a loss of thousands of dollars in sweet potatoes in

the South ; whereas among the virtues claimed for the conversion of the tubers into silage are the absence of loss from storage, reduction of required space for preservation, and no waste in feeding.

Chemical analyses of sweet potato silage and corn silage fail to disclose any appreciable difference. The former has a moisture content of 54·87 per cent., crude protein 1·82, nitrogen-free extract 39·41, fibre 1·48, fat 0·66, and ash 1·85 per cent. Silage manufactured from matured corn analyzes as follows : Moisture 73·7 per cent, crude protein 2·1, nitrogen-free extract 15·4, fibre 6·3, fat 0·8, and ash 1·7 per cent. Feeding experiments in Florida have justified the claims that 100 pounds of sweet potato silage will replace from 150 to 200 pounds of corn silage in the ration. The uneven ratio favouring the feeding value of the potato product is attributed to a minimum water content, and the presence of two and one-half times as much nitrogen-free extract as the corn silage.

Comparative tests to ascertain the relative feeding values of sweet potato silage and *Sorghum* silage in the production of milk yielded the following results : The cows subsisting on sweet potato silage, wheat bran, and cotton-seed meal produced 2,641 pounds or 307·1 gallons of milk. For a corresponding period of time, cows fed on *Sorghum* silage, wheat bran and cotton-seed meal yielded 2,415·8 pounds or 280·9 gallons of milk. [*Scientific American*, Vol. CXXIV, p. 73 ; dated 22nd January, 1921.]

PERSONAL NOTES, APPOINTMENTS AND TRANSFERS, MEETINGS AND CONFERENCES, ETC.

MR. G. S. HENDERSON, N.D.A., N.D.D., Imperial Agriculturist, Pusa, is appointed substantive *pro tempore* Joint Director, Agricultural Research Institute, Pusa, from the 1st March, 1921.

With effect from the same date, Mr. Henderson is appointed, in addition to his own duties, to act as Imperial Dairy Expert.

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MR. W. MCRAE, M.A., B.Sc., F.L.S., substantive *pro tempore* Imperial Mycologist, has been granted combined leave for one year from the 5th January, 1921.

From the same date, Dr. F. J. F. Shaw, A.R.C.S., F.L.S., Second Imperial Mycologist, and Mr. J. F. Dastur, M.Sc., D.I.C., Supernumerary Mycologist, Pusa, are appointed to officiate respectively as Imperial Mycologist and Second Imperial Mycologist, during Mr. McRae's absence on leave.

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MR. T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S., was substantive *pro tempore* Joint Director, Agricultural Research Institute, Pusa, from the 5th January to the 28th February, 1921, in addition to his own duties as Imperial Entomologist.

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MR. W. SMITH, Imperial Dairy Expert, has been granted combined leave for eight months.

***

MR. G. F. KEATINGE, C.I.E., I.C.S., Director of Agriculture, Bombay, is granted, from the 28th February, 1921, combined leave for eight months.

DR. HAROLD MANN has been appointed to act as Director of Agriculture, Bombay, during the absence on leave of Mr. G. F. Keatinge.

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MR. S. L. AJREKAR, B.A., has been appointed Plant Pathologist, Bombay Presidency.

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MR. M. H. SOWERBY, M.R.C.V.S., Assistant Principal, Bombay Veterinary College, has been granted combined leave for six months from the 1st May, 1921. Mr. N. D. Dhakmarwala is appointed to officiate.

***

MR. R. K. BHIDE has been appointed to act as Plant-breeding Expert, Bombay, relieving Mr. W. J. Jenkins.

***

MR. E. S. FARBROTHER, M.R.C.V.S., Superintendent, Civil Veterinary Department, Sind, Baluchistan and Rajputana, has been granted combined leave for one year, Khan Bahadur S. G. Haji officiating.

***

MR. CHELVARANGA RAJU GARU, Deputy Director of Agriculture, Madras, has been permitted to retire from service.

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RAI BAHADUR K. RANGA ACHARIYAR, M.A., Government Lecturing and Systematic Botanist, has been allowed privilege leave for one month, Mr. C. Tadulingam officiating.

***

MR. A. C. EDMONDS, Deputy Director of Agriculture Madras, has been placed in charge of I Circle, Cocanada.

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MR. D. BALAKRISHNA MURTI has been appointed to officiate as Deputy Director of Agriculture, II Circle, Madras Presidency, with headquarters at Gantur.

MR. D. G. MONRO, Deputy Director of Agriculture, Madras, has been placed in charge of II Circle, Trichinopoly.

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MR. M. GOVINDA KIDAVU, Assistant Director of Agriculture in charge of VII Circle, has been appointed to act as Deputy Director of Agriculture, VII Circle, Madras Presidency.

***

MR. P. T. SAUNDERS, M.R.C.V.S., has been appointed to the Indian Civil Veterinary Department and is posted to Madras.

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MR. R. S. FINLOW, B.Sc., F.I.C., Fibre Expert to the Government of Bengal, has been granted combined leave for ten months.

***

RAI SAHIB APURBA KUMAR GHOSH, Superintendent of Sericulture, is appointed to act as Deputy Director of Sericulture, Bengal, until further orders.

***

THE services of Mr. B. C. BURT, M.B.E., B.Sc., Deputy Director of Agriculture, Cawnpore, have been placed at the disposal of the Government of India, Department of Revenue and Agriculture, for appointment as Secretary, Central Cotton Committee.

***

MR. P. K. DEY, M.Sc., Plant Pathologist to Government, United Provinces, was on privilege leave for one month and one day from the 15th February, 1921.

***

DR. H. E. ANNETT, Opium Research Chemist, has been appointed to officiate as Principal, Agricultural College, Cawnpore.

***

DR. T. M. SINGH, Assistant Agricultural Chemist, has been appointed to officiate as Agricultural Chemist to Government, United Provinces.

MR. W. N. HARVEY, M.S.E.A.C., Deputy Director of Agriculture, United Provinces, has been granted permission by His Majesty's Secretary of State for India to return to duty.

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MR. P. B. RICHARDS has been appointed to the Indian Agricultural Service and posted as Entomologist to Government, United Provinces.

***

MR. A. C. DOBBS, B.A., Director of Agriculture, Bihar and Orissa, has been granted combined leave for ten months.

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MR. E. L. TANNER, I.C.S., Director of Land Records and Surveys, has been appointed to act as Director of Agriculture, Bihar and Orissa, in addition to his own duties, during the absence of Mr. Dobbs on leave.

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MR. C. SOMERS TAYLOR, B.A., Principal of the Agricultural College at Sabour, and Agricultural Chemist to the Government of Bihar and Orissa, has been granted combined leave for eight months.

MR. G. C. SHERRARD, B.A., officiates as Principal in addition to his own duties as Professor of Agriculture, and Mr. M. N. Ghosh, M.A., as Agricultural Chemist, until further orders.

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MR. D. MILNE, B.Sc., has, on return from leave, resumed charge of his duties as Economic Botanist to Government, Punjab.

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CAPTAIN K. J. S. DOWLAND, M.R.C.V.S., Professor of Sanitary Science, Punjab Veterinary College, Lahore, has been attached to the office of Chief Superintendent, Civil Veterinary Department, Punjab, for training.

CAPTAIN E. SEWELL, M.C., M.R.C.V.S., has taken over charge of his duties as Post-Graduate Professor, Punjab Veterinary College, Lahore, relieving Mr. W. Taylor, Professor of Pathology and Parasitology, of the additional duties of Post-Graduate Professor.

***

MR. DAVID HENDRY has been appointed to the Indian Agricultural Service and posted to Burma as a Deputy Director of Agriculture.

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MR. A. MCKERRAL, M.A., B.SC., Deputy Director of Agriculture, Burma, has been transferred from the charge of the Southern Circle to the charge of the Northern Circle, with headquarters at Mandalay.

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MR. R. A. BEALE, Assistant Botanist, Burma, has been placed in charge of the current duties of the Deputy Director of Agriculture, Southern Circle, with headquarters at Insein, *vice* Mr. McKerral transferred.

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CAPTAIN J. B. IDLE, who has been appointed to the Indian Civil Veterinary Department, has been posted to Burma.

***

MR. S. K. MITRA has been appointed, on probation, Economic Botanist, Assam.

Reviews

Lessons on Indian Agriculture.—By D. CLOUSTON, C.I.E., Director of Agriculture, Central Provinces. Pp. x + 224 + 58 text-figures. (London: Macmillan & Co., Ltd.) Price, 3*s*. 6*d*.

THIS book, prepared by a Director of Agriculture, and consisting of a series of chapters on soils, cultivation, manures, etc., with further chapters dealing with entomology, cattle diseases and co-operation, is of interest from several points of view. As pointed out by Mr. J. Mackenna, late Agricultural Adviser to the Government of India, in his foreword, it has been written by one who has, for the last fifteen years, been working in the Agricultural Department, and who, having this practical experience, is specially fitted to write about Indian agriculture. We welcome the book for more reasons than one. First, because it is so written that it can be used either as a text-book in agricultural schools and in the junior classes of an agricultural college or even as a reader in ordinary schools. Secondly, the author's treatment is so clear that it should enable the majority of schoolmasters to grasp what they are going to teach, with the result that they will be able to expound the lessons in such a manner as to stimulate the students' curiosity and arouse a more intelligent interest in their surroundings. Another welcome feature of the book is that it can be used as a text-book in any part of India, as it deals with the broad principles of agricultural practice as affecting this country, the principal crops grown, etc. With the insistent cry now being raised in the press and in the councils for the improvement of rural education, and the desire to make it less literary and more of a nature that will enable the students after their school life to step into their ancestral vocation with a mind trained to observe and to

experiment, the need of suitable text-books is very great, and we have no hesitation in saying that Mr. Clouston's book under review should supply a long-felt want in this direction.

Turning to details, while the size of the book is handy and the printing good and clear, we have noticed several misprints which we should not have expected in a book printed in the United Kingdom. No uniformity has been observed in printing vernacular names. The same word is printed sometimes in italics and sometimes in Roman type. The glossary at the end is not exhaustive enough.

The illustrations on the whole are good and clear. But figure 26 on page 93 is printed upside down, and the illustration of a good Indian milch cow on page 187 leaves much to be desired. In its place, a photograph showing the good points of an Indian milch cow would have been most appropriate, and it would surely have been possible to obtain one. We make this remark because we feel convinced that many good photographs showing these points are available, and the inclusion of one such would have greatly enhanced the educational value of the book.

These are, however, minor defects which we are sure the author will put right when a second edition is brought out. The compilation must have cost the author many weary hours of labour, and we wish the book all success. [W. S.]

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Poultry-Keeping in India.—By Isa Tweed. New Edition. (Calcutta, Thacker, Spink & Co.) Price, Rs. 6.

Isa Tweed's latest edition of her popular book on poultry-keeping in India aims at helping people in this country to understand how to breed poultry so that it should be both a source of pleasure and profit. The opening chapter of the book strikes the right note by pointing out that poultry-keeping is not to be lightly regarded as an unimportant occupation for the uneducated and lower classes, but as an industry that should occupy the attention of the intelligent man and woman, both from the point of view of an increasingly important source of food production and also from the point of view of offering

a most important field of work for the student and investigator of problems of biology.

The industry has taken a very large and prominent place in the agricultural development of other progressive countries in the world, but in India its importance has scarcely been realized, and except for the effort of a small minority its immense possibilities have been practically untouched. As Isa Tweed points out, properly organized, it should prove an admirable cottage industry most suited to supplement the incomes of the masses of depressed classes in India, and missionary societies and other philanthropic persons would do well to consider this. Valuable advice is given in the book on the important question of housing poultry, though the houses illustrated appear more suited to the colder climate of the hills than that of the plains, but with open sides and fronts of wire netting, instead of wood work, this difficulty is easily surmounted.

The question of feeding fowls is always the first difficulty of the novice, and the chapter on foods explains in simple language the feeding values of the various feeding stuffs available. To be critical, it would have been a help to the novice to have had more exact directions as to quantities and proportions, as it is well known that a balanced diet is a very important factor in the production of eggs and table fowls, and that ignorance on this matter hampers success.

Breeding and selection of stock is fully dealt with, and valuable advice on natural and artificial incubation and management of chickens is also given. The treatment for sick fowls is admirable. Many of the prescriptions given have been tested with success on the Government Poultry Farm, Lucknow.

We do not see eye to eye with the author on some points, such as, for instance, the question of egg production and fertility. We consider that a hen producing only 120 eggs per annum is not worth the cost of her food. We think the hen producing 180 to 200 eggs a year, and even more, can still be relied on for laying a high average of fertile eggs. We concede that very high records are prejudicial to fertility, but very few egg farmers in these days would care to keep fowls whose average did not exceed 120 per annum. With feeding stuffs at such a high price, greater production of eggs is imperative in

order to make poultry-farming a profitable investment. Also, we think that imported poultry do a great deal better in India than Isa Tweed claims, and the large and increasing number of poultry fanciers in India, who import from England and Australia, would go to prove that their experience does not bear out what Isa Tweed states.

Poultry-farming methods in other countries have of recent years made such enormous strides in improvement that it is almost impossible for any book to keep up to date, but Isa Tweed has succeeded in giving the poultry farmer in India a most comprehensive and instructive book written in simple language that cannot fail to be of the greatest assistance to him in a country where so little knowledge or help is available. We trust it will not be long before Government takes up the matter in every province. [A. K. F.]

NEW BOOKS

ON AGRICULTURE AND ALLIED SUBJECTS

1. Insect Life, by C. A. Eland. Pp. xii+340+lxxiv plates. (London: A. and C. Black.) Price, 30*s*. net.
2. Agriculture and Irrigation in Continental and Tropical Climates, by Kinsley D. Doyle. Pp. xv+268. (London: Constable and Co.) Price, 19*s*. net.
3. An Introduction to Bacterial Diseases of Plants, by Erwin F. Smith. Pp. xxx+688. (Philadelphia and London: W. B. Saunders and Co.) Price, 50*s*. net.
4. An Introduction to the Chemistry of Plant Products, by Dr. H. P. Haas and T. G. Hill. Vol. I. On the Nature and Significance of the Commoner Organic Compounds of Plants. Third Edition. Pp. xiii+414. (London: Longmans, Green and Co.) Price, 16*s*. net.
5. Types and Breeds of Farm Animals, by Prof. C. S. Plumb. Revised Edition. (Coun tryLife Education Series.) Pp. viii+820. (Boston and London: Ginn and Co.) Price, 16*s*. 6*d*. net.
6. The Breeding and Feeding of Farm Stock, by J. Wilson. Pp. vii+152. (London: Methuen and Co.) Price, 6*s*. net.
7. A Book of Butter: A Text on the Nature, Manufacture, and Marketing of the Product, by Prof. E. S. Guthrie. Pp. xv+270. (London: Macmillan and Co.) Price, 12*s*, net.
8. Farm Management, by J. H. Arnold. Pp. vii+243. (London: Macmillan and Co.) Price, 7*s*. 6*d*. net.
9. Farm Crops Laboratory Manual and Note Book, by F. W. Lathrop. Pp. 118. (Philadelphia and London: J. B. Lippincott Co.) Price, 4*s*. 6*d*. net.

10. Indian Hand-book on Ducks, Geese, Turkeys, Guinea-fowls, Pigeons, Pea-fowls and Rabbits, by Isa Tweed. Second Edition. (Calcutta : Thacker, Spink & Co.) Price, Rs. 4-8.

THE following publications have been issued by the Imperial Department of Agriculture since our last issue :—

Memoirs.

1. The Retention of Soluble Phosphates in Calcareous and Non-Calcareous Soils, by W. H. Harrison, D.Sc., and Surendra Lal Das, M.Sc. (Chemical Series, Vol. V, No. 9.) Price, R. 1 or 1*s*. 4*d*.
2. Indian Grass Gall Midges, by E. P. Felt. (Entomological Series, Vol. VII, No. 3.) Price, As. 10 or 1*s*.

Bulletins.

3. *Ustilago Crameri*, Koern. on *Setaria italica*, by S. Sundera-raman, M.A. (Bulletin No. 97.) Price, As. 4.
4. The Course that Surra runs in Camels when Naturally Contracted and when Artificially Inoculated, by H. E. Cross, M.R.C.V.S., D.V.H., A.Sc. (Bulletin No. 98.) Price, As. 5.
5. The Course that Camel Surra runs in Ponies, Buffaloes and other Animals, by H. E. Cross, M.R.C.V.S., D.V.H., A.Sc. (Bulletin No. 99.) Price, As. 4.
6. Instructions for Rearing Mulberry Silkworms, by M. N. De, (Bulletin No. 39: Third Revised Edition.) Price, R. 1-3.

Report.

7. Annual Report of the Imperial Bacteriological Laboratory, Muktesar, for the year ending the 31st March, 1920. Price, As. 5.

THE BLACK DRONGO OR KING CROW (*DICRURUS MACROCERCUS*).

Original Articles

SOME COMMON INDIAN BIRDS.

No. 10. THE BLACK DRONGO OR KING CROW (*DICRURUS MACROCERCUS*).

BY

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AND

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THE haphazard manner in which we are dealing with our common birds may appear to demand some sort of apology, but the apparent lack of arrangement is simply due to nothing but the relative rate at which it is possible to give suitable illustrations of the various birds dealt with. Generally speaking, it is necessary to paint the plate of each feathered friend or foe, with its natural leafy or other background, including in many cases its nest and eggs, at a particular time of the year, and it may chance for various reasons that it is not possible to secure a life-like portrait of any particular bird in its natural haunts in time to enable a plate to be painted just when it is required.

The Black Drongo or King Crow is one of our most common and familiar birds, occurring especially in all cultivated areas and being fond of perching on any suitable upright twig or other support from which it can swoop down to secure its prey, either on the wing or on the ground. The prey consists almost wholly of insects,

and practically wholly of injurious insects, so that this bird is most distinctly a valuable ally of the farmer and deserves every encouragement and protection.

The Drongos form a family of birds well defined by their black plumage and long forked tail composed of ten feathers. Less than twenty species occur within Indian limits and these are divided into about seven genera, again subdivided into two groups according to the relative lengths of the outer tail-feathers. In one group, in which these feathers exceed the middle ones by at least twice the length of the wing, we may briefly notice the Larger Racket-tailed Drongo (*Dissemurus paradiseus*), which occurs in practically all the more hilly parts of India and Burma, is black, glossed with blue, with a tuft of feathers on its forehead, and which has a really fine song and, according to Oates, is perhaps the best singing-bird of the East. In the other group, characterized by the outer tail-feathers not exceeding the middle ones by so much as the length of the wing, we have the genus *Dicrurus*, with an untufted forehead and a deep bill, comprising about eight Indian species, amongst which *D. macrocercus* is distinguished by its entire plumage being a deep glossy black and its outermost tail-feather exceeding the middle pair by a distance greater than twice the length of the tarsus. The Black Drongo is the commonest bird seen near dwellings in the Plains and any jet-black bird, about the size of a bulbul, with a long forked tail, seen in cultivated areas in the Plains, is likely to be this bird. The whole plumage is deep black, everywhere glossed with steel-blue, the latter character being perhaps rather accentuated in our Plate, which shows a small white spot which is sometimes present at the angle of the gape. Young birds have the wings and lower plumage brownish mixed with white. and very old birds may be entirely black.

The specific name *ater*, under which the Black Drongo has hitherto been referred to as a rule in Indian literature, of course means black, in reference to the colour of this bird, but it is a feeble name to have been bestowed on it, and a name such as *audax* would seem better suited to a bird of this character. Its alternative name

of King Crow is probably derived from the fierce manner in which it attacks and drives away any crows which approach near its nest during the breeding season. Except for its colour it is not itself crow-like either in build or disposition. In its nature, indeed, it partakes of a good deal of the piratical, watching from its perch above until some industrious Hoopoe or Mynah has found a tasty morsel of insect food and then swooping down and robbing the rightful owner with a dexterity evidently only acquired by a regular course of original sin in the line of highway robbery. The victim, if it be a Mynah or similar bird, sometimes shows fight or endeavours to escape with its prize, but the Hoopoe is more of a philosopher and allows itself to be robbed almost with impunity, merely ruffling up its feathers and then starting in again to peck away in the ground in the search for another grub.. In any case the result is usually the same, and the Drongo secures the spoil and flies off with it to its perch. This little comedy may be seen enacted daily in almost any Indian garden, especially when the Hoopoe has young and is collecting food to take back to the nest, and it is noticeable that the Drongo only levies just enough toll not to discourage its victims unduly and drive them away altogether.

The Drongo, however, is by no means wholly a parasite, living at other birds' expense, but catches for itself the larger proportion of its food. The late C. W. Mason examined the contents of twenty-seven adult and four young birds at Pusa and Mr. D'Abreu has recorded the contents of seven birds at Nagpur, and these records show that the food consists entirely of animal matter, practically wholly of insects and in an overwhelming proportion of injurious insects, such as crickets, grasshoppers, moths, bugs, and insect larvæ. The prey is captured either on the wing or on the ground, in which case the bird swoops down upon it and either eats it forthwith or flies off with it to its perch. Mr. Mason gives a long and interesting account of the feeding-habits (*Ind. Agric. Entl. Mem.*, Vol. III, pp. 69—79 ; Jan. 1912), which we need not reproduce here. The Drongo is one of the birds which accompany cattle, often perching on their backs, but apparently rather for the sake of the grasshoppers and other insects disturbed by the

movements of the animals than for the sake of the flies which annoy them. It is also a regular visitor to ploughing operations, perching on upstanding clods or other convenient ventage-spots, and picking up cutworms and other insects exposed by the plough. As Mason notes, however, " he is by no means active on the ground under the best circumstances," his long tail, which serves so well as an organ of flight, seeming to get in the way when on the ground. It is noticeable that the Drongo never hunts on the ground for insects, but always watches from some convenient perch, swooping down to capture insects seen on the ground. The Drongo is naturally a pugnacious and fearless bird, attacking without hesitation birds much larger than itself. At the breeding-season its natural pugnacity is much augmented and it drives away any bird, especially crows, which dare to approach the tree in which its nest is placed. As noted in our last paper, the Indian Oriole frequently builds in the same tree as the Drongo, the latter thus serving to protect the Oriole's nest as well as its own, and at the moment of writing these lines there is within a few yards of my bungalow a *sissu* tree in which a pair of Drongos and of Indian Orioles have each a nest quite close to one another. A pair of Jungle Crows commenced the nesting-season by building in the topmost branches of the same tree, but now they dare not approach it and probably the young crows have flown by now in any case. Drongos sometimes fight amongst themselves and I have seen a couple so intent on squabbling on the ground that a jackal was able to run up, knock them both down with its forepaws and carry them off.

The nesting-season of the Black Drongo is from April to August but May is the usual time in Bihar. The nest, which is a broad shallow cup, is usually placed fairly high up in a tall tree in some fork of a branch not quite on the outside of the tree ; it is composed of small twigs and stems and roots of grass, neatly and tightly fastened together, and bound around on the outside with more or less cobweb, in which a few feathers are sometimes entangled. The cavity is broad and shallow, about four inches broad by one and a half deep, and lined with horse-hair or fine grass

stems or roots; the bottom of the nest is very thin, but the sides are rather thick and firm. Four eggs is the normal number, but there may be three or five at times. The egg is either dull pure white without markings or pure white sparsely spotted with deep blackish brown pure creamy pink blotched with reddish-brown to deep salmon-pink blotched with claret-colour; it is noticeable that all the eggs of one clutch nearly always seem to belong to one or other of these types but Mr. C. M. Inglis has found a clutch with two white eggs and one spotted one; the average size of the egg is about 25 mm. long by 19 mm. broad.

The Drongo is protected by law throughout the whole year in Delhi, the United Provinces, Bengal, Assam, and Burma. It is, as already remarked, a most useful bird which deserves every protection and encouragement. The latter aim can be attained, in the case of cultivated areas, by the provision of suitable perches for the birds to rest on.

This Drongo has long been known to Indian ornithologists as *Dicrurus ater* but its correct name seems to be *Dicrurus macrocercus*, Vieill.; it is divided into four races, of which the typical one, *D. macrocercus macrocercus*, ranges throughout India to the foothills of the Himalayas; the Himalayan form, *D. macrocercus albirictus*, ranges from the Himalayas to the Northern Chin Hills; the Burmese subspecies, *D. macrocercus cathoecus*, is found in Burma, Siam, and South China; and the southern form, *D. macrocercus minor*, occurs in Ceylon and doubtfully in Travancore.

It is on the wing until well into the dusk and is one of the earliest birds to call in the morning and may at times be heard throughout the night. It has a variety of notes and is an excellent mimic. Donald records that he has heard one imitate a *shikra* (*A. badius*) so as to frighten away a pair of Mynahs and thus secure a worm which they had caught.

Mr. C. M. Inglis has seen one chase a Laggar Falcon (*Falco jugger*), but in this case the tables were turned, for the falcon stopped in its flight and the Drongo shot ahead and was captured by the falcon. The smaller bird in our plate is shown attacking

one of these falcons which had approached its nest, shown on a tree in the background.

Although the Black Drongo is so pugnacious and intelligent, it is sometimes imposed upon by the Drongo Cuckoo (*Surniculus lugubris*), a bird which is itself most remarkably like a Drongo in general appearance and which lays its eggs in Drongos' nests.

A PRELIMINARY CLASSIFICATION OF THE WILD RICES OF THE CENTRAL PROVINCES AND BERAR.*

BY

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INTRODUCTION.

THE investigations described in this paper form part of the work undertaken by Dr. R. J. D. Graham and myself during the years 1914 to 1920 in connection with the multiplicity of forms met with in the ordinary cultivated rices and the amount of crossing taking place in the same. The earlier results of these dealing with the classification of the cultivated rices of the Central Provinces and Berar are to be found in the *Memoirs of the Department of Agriculture* (*Botanical Series*, Vol. VI, No. 7) by Dr. Graham. The present work was undertaken later on to investigate the character and nature of the wild rices found growing in the "nalas" and waste lands of these provinces.

The economic importance of the study of wild rices may be said to be twofold: (1) They form an important weed in the rice-growing areas of the Central Provinces and have often been the means of heavy loss to the cultivators; (2) they are a frequent source of contamination of the cultivated rices through casual mixture and natural crossing.

The varieties commonly met with in these parts have been fully described in this paper and an attempt has been made at their

* A paper read at the Eighth Indian Science Congress, Calcutta, 1921.

classification in order to facilitate, as much as possible, their recognition in the field.

Seeds of over 100 different samples of wild rices were obtained from all the districts of these provinces mainly through the help of the district officers and were sown on the College Farm, Nagpur. In most cases, except where whole ears were available, the samples were found to be mixture of varying proportions of the different types of wild and cultivated rices. By single plant selection, ears of 536 individual plants were collected separately and line cultures easily obtained. It is hoped therefore that as many types as probably occur in these parts have thus been obtained and isolated.

OCCURRENCE.

The wild rices are found growing in practically all the rice-growing tracts in the Central Provinces, but are found more abundantly in Raipur, Bilaspur, Balaghat, Seoni and Chanda Districts. They generally grow on the margins of tanks, rice fields and other marshy or low-lying places, not actually submerged but which contain enough moisture to carry them through the season. The wild rices growing in tanks are usually tall, having the power of adapting themselves to the depth of water in which they grow, and their grain takes longer to mature. In the Central Provinces, the Gonds and Dhimars harvest this rice by tying the plants together into clumps and thus preventing the grains from falling. These grains have also got a certain demand in the market as they are often used by devout Hindus in these parts on fast days besides being sold to the poorer classes.

CHARACTERISTIC FEATURES OF THE WILD RICES.

Morphologically there is very little difference between a wild and a cultivated rice but generally speaking it may be recognized by the spikelets having dark red grains inside, by the presence of long stout awns which are red, scarlet or green in colour, and lastly by its characteristic nature of shedding the spikelets in green stage, long before they appear to have become perfectly ripe. This habit

in the plants involved considerable difficulty in collecting the grains for seed purposes, and each plant had to be carefully examined every morning to make sure that the grains would not drop off during the day. It was, however, found very useful to tie a piece of thread all round the ear, particularly the awns, so that, even when getting loose on ripening, the grains were held up in a mass by the thread and prevented from falling. The ripe grains in many of the varieties sometimes develop a peculiar light black or ashy colour to which the name of " wild " type colour has been given in these pages. This colour is not generally found on cultivated rices and is a special feature of a number of varieties of the wild ones.

The awned wild rices seem to agree with *Oryza sativa* var. *fatua* Prain. A wild rice from Raipur with a dirty white grain and an awnless wild rice from Bhandara appear to be cultivated rices run wild. Watt records the discovery by Duthie of *Oryza officinalis* Wall. (syn. *O. latifolia* Desv.) in Chanda. This wild rice differs from the others in having multi-veined leaves.

The popular belief that a cultivated rice if not looked after properly, *i.e.*, with regard to transplanting, nursery-sowing, etc., will become converted into a wild rice within three years and *vice versa*, appears to be extremely doubtful. The wild rices had been grown on the Nagpur farm for the last seven years exactly under cultivated conditions, *i.e.*, sowing in nurseries and transplanting them like ordinary cultivated rices, and yet they have apparently retained all the features, habits and characteristics of the wild rices, *viz.*, the shedding of the grains, red awns and so forth. The cultivated ones which had apparently run wild could also be very easily identified by the absence of the above-mentioned characters without much difficulty. The occurrence of the wild rice called *tarra*, the grains of which do not fall, mixed with many of the cultivated varieties, suggests the occurrence of natural cross-fertilization between the wild and the cultivated forms.

POLLINATION.

The normal pollination in wild rices is rather a little different from that of the ordinary cultivated rices. In the latter the glumes

open out between 8 and 9 o'clock in the morning and remain open for about half an hour only and then close up. The pollination generally takes place inside the closed glumes, the anthers bursting either before the opening of the glumes or just at the time of opening. Consequently self-pollination is the rule. During a period of 12 years' work on the cultivated rices at Nagpur, only one instance of natural crossing was found to occur. In wild rices, however, it is different. The glumes open out between 8 and 9 A.M. as in cultivated rices, but remain open for a longer period, about an hour or so, and the anthers do not burst till they get slightly warmed up by the heat of the sun, for about two to five minutes. The stigmas come out immediately on the opening of the glumes and remain expanded on either side. The anthers extrude slightly above the glumes and remain in that position for some time and then fall over and assume the pendent position. Occasionally they do dehisce before falling over, and self-pollination takes place directly, but, as a rule, they do not dehisce till about two to five minutes of the opening of the glumes. During this period the chances of cross-pollination are certainly considerable and hence apparently the much higher percentage of crossing met with in the wild rices than in the ordinary cultivated ones.

It has been noticed, however, that all the anthers of a flower do not always assume the pendent position. Generally one, rarely two out of six anthers are always found to remain sticking inside and never come out. These also dehisce along with the other anthers and ensure the pollination of the stigmas if they have not been already pollinated. It may be noted, however, that the time of opening of the flowers and its duration depend to some extent on the temperature. If the weather is comparatively cool and the temperature low, the flowers open at about 10 o'clock in the morning and the glumes remain open for a longer period.

NATURAL CROSSING.

On working out the above mentioned collection of wild rices by single plant selection (the outturn in each case being from one single ear) it was found that, though the majority of the lines bred

true, some of them showed distinct signs of splitting, proving the selected plants to have been heterozygotes. Besides, a few of them split into a number of varied forms, sometimes into as many as seven different varieties. This indicated the enormous amount of crossing and recrossing that had already taken place in them, with the result that forms appeared in the progeny which apparently had no resemblance whatsoever with the parent. More often cases of simple crossing were also detected, the progeny splitting more or less in Mendelian proportions of 3 : 1. For instance, in 1916 seeds of a single ear with black inner glumes were sown in a line and it was found to be splitting into 48 plants with black glumes and 14 with straw-coloured glumes, roughly in the proportion of 3 : 1. (For the sake of convenience, the original plant, which proved to be heterozygous, will be referred to as F_1 and their progeny as F_2, F_3, etc.). The ones with straw-coloured glumes, on sowing again in their F_3 generation, bred true to the type and produced only plants with straw-coloured glumes, showing apparently the recessive character ; while the "blacks," on the other hand, behaved in their F_3 generation : some as pure dominants breeding true "blacks," others, as segregating hybrids, splitting again into black and straw-coloured glumes. Here the black colour, in the inner glumes, showed dominance over the straw colour, as has also been shown to be the case in the cultivated rices by Mr. Parnell.[1] As these experiments, however, were not really intended for the working out of the Mendelian characters, the seeds of all the plants in the F_2 generation were not sown the next year but only a small proportion taken up just to get an indication of the nature of the segregation taking place in these, *i.e.*, the behaviour of the heterozygotes as well as that of the recessives. Instances of crossing of four unit characters such as red leaf-sheath with spikelets clustered and green leaf-sheath with spikelets not clustered were also obtained giving all the four forms in different combinations, such as (1) plants with red leaf-sheath and spikelets clustered, (2) plants with green leaf-sheath and spikelets clustered, (3) plants with red

[1] *Mem. Dept. Agri. India, Bot. Ser.*, Vol. IX, No. 2.

leaf-sheath and spikelets not clustered and (4) plants with green leaf-sheath and spikelets not clustered. Owing to the meagreness of the number of plants obtained in these, the proportions of 9 : 3 : 3 : 1 were not very clearly demonstrable.

The following table gives the results of the F_2 generation of some of the natural crosses obtained in the wild rices during the years 1917 to 1919.

TABLE I.

Coloured (red) and green leaf-sheath.

Origin of parent	Reference No.	Red plants	Green plants
Natural cross.	36–B	15	5
Ditto	41–B	34	8
Ditto	95–C	15	7
Ditto	53–D	8	3
Ditto	61–D	5	2
Ditto	74–D	7	3
Ditto	84–D	5	2
Ditto	87–C	28	6
Ditto	78–C	3	1
Ditto	36–B	13	6
Ditto	26–B	24	10
TOTAL	..	157	53
CALCULATED	3 : 1	157·50	52·50

From the above figures it will be seen that the character of the coloured leaf-sheath, irrespective of the actual amount of shade of red and purple in it, behaves as the dominant character to that of the green leaf-sheath, and splits in the Mendelian proportions of 3 : 1. A few instances have also been obtained of the same characters giving approximately a 9 : 7 ratio, as shown in Table II, bearing out the "presence and absence hypothesis"; but such instances were very few, the 3 : 1 ratio being by far the more

common. Moreover, the numbers also are too small to permit of a definite interpretation but may possibly indicate a 9 : 7 ratio.

TABLE II.

Coloured and green leaf-sheath. 9 : 7

Origin of parent	Reference No.	Red plants	Green plants
Natural cross	50 red-A	16	12
Ditto	33-B	13	9
Ditto	26-A	14	10
TOTAL		43	31
CALCULATED	9 : 7	41·63	32·37

The characters of the black and straw-coloured inner glumes of the ripe grain also furnish materials for the demonstration of the 3 : 1 ratio. Table III gives below the counts made in a number of lines for black and straw-coloured ripe grains indicating segregation for a single factor only. This is in accordance with the results obtained by Mr. Parnell at Coimbatore in the cultivated rices where only one factor was involved.

TABLE III.

Black and straw-coloured grains.

Origin of parent	Reference No.	Black	Straw
Natural cross	31-B	31	9
Ditto	34-B	11	1
Ditto	38-B	41	14
Ditto	99-B	24	12
Ditto	66-A	48	14
Ditto	88-D	28	11
Ditto	109-D	15	4
TOTAL		198	65
CALCULATED	3 : 1	197·25	65·75

However, enough evidence has been obtained to show that natural cross-fertilization takes place more freely in these than in the cultivated rices. Out of 281 single line cultures sown in 1916 from individual ears, 35 lines were actually found to be splitting. In addition, from apparently pure lines breeding true for at least two previous generations, a certain number of instances of undoubted crossing was detected.

Table IV below gives figures indicating the actual amount of crossing that has taken place in the pure line cultures of the wild rices on the Nagpur farm during the years 1917 to 1920.

TABLE IV.

Amount of natural crossing.

Year	Number of pure lines from individual plants	Number of lines splitting	Percentage of crossing
1917	90	8	8·8
1918	97	5	5·1
1919	52	4	7·7
1920	40	5	12·5
TOTAL	279	22	7·9 per cent.

It will be seen from the above figures that the amount of natural crossing taking place in the wild rices growing in adjacent lines, on an average, comes to about 7·9 per cent.

The following characters have been found to behave as Mendelian units in the wild rices :—The green or red colouring of the leaf-sheath, black or straw colour of the ripe grain and the clustering or non-clustering habit of the spikelets ; and of these, the characters of the coloured leaf-sheath, the ripe black grain and the clustered spikelets have been found to be dominant and segregating characters.

ECONOMIC ASPECT.

The wild rice or *karga*, as it is called in these parts, forms a most obnoxious weed in the rice lands, and owing to its close

resemblance to the ordinary cultivated rice, except when flowering it becomes extremely difficult to get rid of. As already stated, its grains fall off very quickly, long before they appear to have become quite ripe and remain on the ground without germinating till the next monsoon season when the *karga* again makes its appearance with the sowing of the ordinary rices and thus becomes indistinguishable from them. The uprooting of it results in a considerable portion of each plot being left without a crop and in the final outturn being reduced to that extent. In the Chhattisgarh tracts the amount of loss due to this is sometimes said to be so great as to reduce the outturn of rice by 50 per cent. Besides, as already stated above, the occurrence of the grains of a wild rice, *tari* or *tarra* as it is called, in many samples of rice received from Raipur, together with the fact that the presence of *tari* in a rice field is held by the cultivators to lead to the deterioration of the crop, naturally suggests the occurrence of natural cross-pollination between a wild and a cultivated rice.

Since the publication of the classification of rices by Dr. Graham only one instance of natural crossing has been found to have occurred in the cultivated rices at Nagpur between a red grained and a white grained variety. Mr. Hector in Bengal[1] and Mr. Parnell in Madras have estimated the amount of natural crossing in cultivated rices to occur to the extent of 4 per cent. and up to 2·9 per cent. in their respective provinces. The occurrence of cross-pollination with greater frequency in the wild rices in the Central Provinces is probably due, as already mentioned above, to the anthers dehiscing sometimes after the opening of the glumes and also to some extent to the longer period that the glumes remain open and the stigmas exposed.

The best method that could be adopted to get rid of these wild forms from a cultivated rice field, is to grow some coloured rice (preferably *nag kesar*—the purple rice) in the fields which show an abundance of *karga* or wild rice. This rice, being purple all over, will allow all the green rice plants to be uprooted without

[1] *Mem. Dept. Agri. India, Bot. Ser.*, Vol. VI, No. 1.

any loss, and if the weeding is done carefully the land will become quite free from *karga* next year. The other alternative would be to keep the land bare of any crop for a period of six to eight weeks after the starting of the monsoon. During this period, however, the seeds of the cultivated rices should be sown in seed beds in a field which is known to be absolutely free from any *karga*. In about six to eight weeks these seedlings would be ready for transplanting and the fallow fields, which by now must have got all the *karga* seeds germinated and grown up, should be thoroughly ploughed so as to uproot all the *karga* plants growing on them. These may then be collected and destroyed and the land should be well puddled. This will ensure, to a considerable extent, the destruction of the wild varieties and the crop of rice following will be more or less free from it.

CLASSIFICATION.

The characters made use of in the classification of the wild rices are mainly those of the leaf-sheaths which may be green or coloured, of the peduncles of the inflorescence which may be exserted from the last leaf (flag) or enclosed by it, and of the colour of the inner glumes of the spikelets both when unripe and ripe. A peduncle is said to be "enclosed" when the lowest branch of the inflorescence is within the leaf-sheath of the flag (*i.e.*, the last leaf) and "exserted" when the lowest branch, easily recognized by its complete ridge of ciliate hairs encircling the stem below the branch, is free from the leaf-sheath. As regards the coloured leaf-sheaths, there are also two types: (1) red and (2) purple. If we take the extremes of these, the two types are certainly distinct from each other, but, as is usually the case, the two colours gradually grade into each other and then it becomes extremely difficult to draw a line of demarcation between the two. For the purpose of this paper they have been grouped together as leaf-sheath red or purple in the key but have been distinguished in their respective colours, wherever possible, in the description of the types. Mr. Parnell has described this colour throughout as purple, but the actual appearance, as he says, varies according to the concentration of the

pigment and the colour of the tissues in which it is present. In this paper it has been referred to throughout as red, unless, as mentioned before, it shows a very distinct purple colouring. With regard to the colouring of the glumes, it has been found that in the earlier stages, the unripe glumes develop a certain colour which, on the ripening of the grain, turns into quite a different one altogether. This holds good for almost all the varieties described. The colour of the unripe glumes also varies considerably in different types. For instance, the glumes, at first green, may often get a dark blackish brown colour developed in them, more especially in the furrows, and after some time, as the grain ripens, often turn into a brown or a deep black colour. The swelling immediately above the node has been described, according to Mr. Parnell, as the pulvinus, and the region joining the lamina and the leaf-sheath has been described as the " junction " either of the lower leaf or of the flag.

ARTIFICIAL KEY TO THE TYPES.

1. Leaf-sheath green.
    - (*a*) Ripe grain black.
        - (i) Glumes green when unripe.
            - † Grain light black (wild type).
                - * Ears enclosed erect approximate. Type 1.
                - * Ears exserted erect spreading. Type 2.
            - † Grain deep black. Type 3.
        - (ii) Glumes with dark furrows when unripe.
            - † Ears spreading.
                - * Plants with spreading habit. Type 4.
                - * Plants erect not spreading. Type 5.
            - † Ears not spreading. Type 6.
    - (*b*) Ripe grain brown.
        - (i) Glumes dark brown when ripe.
            - † Ears spreading. Type 7.
            - † Ears not spreading.
        - (ii) Glumes light brown when ripe.
                - * Ears exserted erect spreading. Type 8.
                - ** Ears exserted curved approximate. Type 9.
    - (*c*) Ripe grain straw coloured. Type 10.

2. Leaf-sheath red or purple.
   (*a*) Ripe grain black.
      (i) Glumes green when unripe.
         † Grain light black (wild type).
            * Ears exserted curved spreading. Type 11.
            * Ears enclosed erect approximate. Type 12.
         † Grain deep black. Type 13.
      (ii) Glumes with furrows when unripe.
         † Glumes with dark furrows.
            * Ears exserted erect spreading. Type 14.
            ** Ears exserted curved lower branches sub-erect. Type 15.
         † Glumes with brown furrows when unripe.
            * Ripe grain light black (wild type).
               (A) Plants with spreading habit. Type 16.
               (B) Plants erect not spreading. Type 17.
            * Ripe grain deep black.
               (i) Ears exserted. Type 18.
               (ii) Ears enclosed. Type 19.
               (iii) Glumes suffused with red when unripe. Type 20.
   (*b*) Ripe grain brown.
            * Ears exserted curved spreading. Type 21.
            * Ears exserted erect approximate. Type 22.
   (*c*) Ripe grain straw coloured.
      (i) Ears enclosed erect approximate. Type 23.
      (ii) Ears exserted curved approximate. Type 24.

DESCRIPTION OF TYPES.

1. Leaf-sheath green. Pulvinus and leaf junction green.[1] Ears enclosed erect approximate. Glumes green when unripe

[1] The pulvinus and the leaf junction have invariably been found to be green in plants with green leaf-sheath, and hence have not been further described in the case of other green plants.

turning wild type. Awns short but complete green. Apiculus green.

2. Leaf-sheath green. Plants very spreading, dwarf. Ears exserted erect spreading. Glumes green when unripe turning wild type when ripe. Awns full, green. Apiculus green.
3. Leaf-sheath green. Plants very spreading. Ears exserted erect spreading. Glumes green when unripe turning black when ripe. Awns full, green. Apiculus green.
4. Leaf-sheath green. Plants spreading. Ears exserted erect spreading. Glumes with dark furrows when unripe turning brownish furrows, finally ripe black. Awns full, green. Apiculus green.
5. Leaf-sheath green. Ears exserted erect spreading. Glumes with slight furrows when unripe turning black. Awns short but complete green. Apiculus green.
6. Leaf-sheath green. Ears exserted erect approximate. Glumes with diffused furrows when unripe turning black when ripe. Awns full, green. Apiculus green.
7. Leaf-sheath green. Plants at first erect, turning spreading. Ears exserted erect spreading. Glumes with furrows when unripe turning brownish furrows finally ripe brown. Awns full, green. Apiculus green.
8. Leaf-sheath green. Plants stout. Ears exserted sub-erect spreading. Glumes green when unripe turning light brown. Awns—tips only. Apiculus green.
9. Leaf-sheath green. Ears just exserted curved approximate. Glumes with faint furrows when unripe, turning light brown when ripe. Awns—few bristles. Apiculus green.
10. Leaf-sheath green. Ears enclosed sub-erect lower branches erect. Glumes green when unripe turning straw when ripe. Awns—long bristles, green. Apiculus green.
11. Seedlings red turning—1st, 2nd and 3rd sheath red, pulvinus green, leaf junction green, flag junction also green. Ears exserted curved widely spreading (branching at right

angles). Glumes green when unripe turning wild. Awns full, red. Apiculus red.

12. Seedlings dark red turning—1st, 2nd and 3rd sheath red, pulvinus dark red. Stem tinged below node, leaf junction black, midrib white, flag junction black. Ears enclosed erect approximate. Glumes green when unripe turning wild. Awns short but complete, scarlet. Apiculus red.
13. Seedlings dark red turning—1st, 2nd and 3rd sheath red. Plants spreading, pulvinus green, knee shaded, faint red ring above, leaf junction white, edges faintly tinged, flag ordinary green. Ears exserted erect spreading. Glumes green when unripe turning black. Awns full, red. Apiculus red.
14. Seedlings red turning—1st, 2nd and 3rd sheath dark red. Plants spreading, pulvinus shaded, red ring above and below, leaf junction with midrib red and edges white, diffused purple above and below, flag ordinary green with diffused purple colouring all over the lamina. Ears exserted erect slightly spreading. Glumes green when unripe turning diffused furrows finally ripe black. Awns full, red. Apiculus red.
15. Seedlings dark red turning faintly red turning again into 1st, 2nd and 3rd sheath pinkish finally fading, leaf junction white, faint red line above, flag ordinary green with a faint red line above. Ears exserted curved lower branches sub-erect. Glumes with dark furrows when unripe turning black. Awns bristles, red. Apiculus red.
16. Seedlings dark red turning—1st, 2nd and 3rd sheath red. Plants very spreading, pulvinus dark. Stem tinged below node, leaf junction white, flag ordinary. Ears exserted erect approximate. Glumes with furrows when unripe turning brown furrows finally wild. Awns full, pink. Apiculus red.
17. Seedlings red turning—sheath tinged. Plants dwarf, pulvinus green, faint red ring above and below. Stem tinged below node, leaf junction ordinary green. Ears hardly exserted

erect approximate. Glumes with faint furrows when unripe turning wild. Awns red, short but complete. Apiculus red.

18. Seedlings dark red turning—1st, 2nd and 3rd sheath dark red spreading, pulvinus shaded, with distinct red ring above and below, leaf junction with midrib red and edges white, and a dark line above and below, flag ordinary, green with a red line above, leaf margins purple. Ears exserted erect approximate. Glumes with brownish furrows when unripe turning ripe black. Awns short but complete, scarlet. Apiculus red.

19. Seedlings red turning—1st, 2nd and 3rd sheath dark red, pulvinus shaded, with a faint red ring above, leaf junction white. Ears enclosed sub-erect approximate. Glumes green when unripe turning brown furrows finally ripe black. Awns red, short and complete. Apiculus red.

20. Seedlings tinged—1st, 2nd and 3rd sheath red. Plants small, very spreading, leaves purple, pulvinus shaded, red ring above, nodes dark red, stem tinged below node, leaf junction faintly tinged outside with midrib white, flag junction white, red line above. Ears exserted erect slightly spreading at first, turning approximate. Inner glumes suffused with red when unripe turning wild, apiculus red, outer glumes red. Awns short but complete, scarlet.

21. Seedlings red turning—1st, 2nd and 3rd sheath purple, pulvinus shaded, leaf junction white, faint red line above and below, flag junction also white with diffused red above and below. Ears exserted slightly curved spreading. Glumes with brown furrows when unripe turning ripe brown. Awns—few bristles. Apiculus red.

22. Seedlings dark red turning—1st, 2nd and 3rd sheath purple. Leaf margin purple, pulvinus shaded, knee dark, leaf junction white, edges dark with faint red line above, flag junction white also with a faint red line above. Ears exserted sub-erect approximate. Glumes green when unripe turning brown furrows finally brown. Awns red, short and complete. Apiculus red.

23. Seedlings dark red turning—1st, 2nd and 3rd sheath purple, leaves purple, pulvinus shaded, knee dark, leaf junction white with dark lines above and below, flag white with a dark line above. Ears enclosed erect approximate. Glumes green when unripe turning straw. Awns—few, short bristles. Apiculus red.

24. Seedlings dark red turning—1st, 2nd and 3rd sheath dark red, finally purple, leaves diffused with purple, pulvinus green, with a red ring above and below, leaf junction white with diffused purple above and below. Flag white having a purple line above and below. Ears exserted curved approximate. Glumes green when unripe turning straw, outer glumes tinged near base ; awnless ; apiculus red.

The types described above are the ones generally met with in these provinces. There are a few sub-types as well which however differ so very slightly from the main types that it has not been considered necessary to include them in this list, each of them being easily referable to one or other of the main types.

I would like to take this opportunity of acknowledging my indebtedness to Mr. K. P. Shrivastava, Offg. Economic Botanist, for the kind help and valuable suggestions given by him during the compilation of this paper.

FURTHER NOTES ON THE EFFECT OF CERTAIN CLIMATIC CONDITIONS ON THE CYANOGENESIS OF *JOWAR* (*ANDROPOGON SORGHUM*).

BY

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OWING to the importance of *jowar* as one of the main fodder crops in India, it is of great interest to ascertain the conditions under which it produces or retains an excessive quantity of hydrocyanic acid. Leather[1] appears to have interested himself in the work as early as 1909, but as he did not get any appreciable quantity of the poison in the crop that he grew, he apparently discontinued the work. Since then some work on this subject has been done at Sabour, the results of which have been published in the journals.[2] A large amount of work has been done in America, notably by Willaman and West[3] who found that richness of the soil is only a very small factor in influencing the formation of the acid, the chief being the climate. Their experiments were not, however, sufficiently conclusive, and lacked confirmation. In fact they found no correlation between the dhurrin content and the atmospheric conditions of temperature and humidity, and merely suggested that a high moisture content of the soil was often accompanied by a low dhurrin content. They also found no real difference in the amounts of the glucoside occurring in the plant between night and day.

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1 *Agri. Jour. India*, I, Pt. 3, p. 220.

2 *Agri. Jour. India*, XI, Pt. 4; XIV, Pt. 1: and *Jour. Dept. Agri. Bihar and Orissa*, III, Pt. 2.

3 *Jour. Agri. Res.*, VI, No. 7, pp. 261–272.

Contrary to the above results, it has been found at Sabour that the atmospheric conditions, *viz.*, temperature and humidity, cause a great deal of difference in the production and the rate of disappearance of the glucoside. Even in cases where the growth of the plant has been retarded owing to unfavourable climatic conditions, the disappearance of the cyanide has been more or less rapid where the temperature has been high. Similarly, with low temperatures, the poison persisted for a long time and did not disappear even when an excessive amount of soil moisture was added.

Mention has been made in an earlier issue of this Journal[1] that a crop of *jowar* planted late in the season after the rains had fully set in, or one growing in a soil containing an excessive amount of moisture, yielded a very low amount of hydrocyanic acid. The suggestion was then made that it was the soil moisture which played a great part in producing the above result. These crops grow best in a season when there is a high humidity accompanied by a high temperature. Their water requirements are not very high and crops have been known to thrive in a soil whose moisture content has not been much higher than 5 per cent. As they require a warm moist climate they are grown here in the rainy season when the weather conditions are favourable. At the same time an abundance of soil moisture is supplied by rain. At the time when the above results were published it was not known whether the low hydrocyanic acid content that was found was associated with the high water content of the soil or with the weather, or with a combination of both. The former is only controllable under field conditions, if *jowar* can be grown here between the months of November and May, when rainfall is not much and the soil moisture can be varied by different amounts of irrigation water. Unfortunately, this is a season of low humidity and one in which the temperature changes from the lowest in January to the highest in May. Attempts were made to find out how the plants will behave as regards cyanogenesis when planted in mid-February and March, and in mid-April and

[1] *Agri. Jour. India*, XIV, Pt. 1.

early May, thus dividing the period of low humidity into periods of fairly high and low temperatures, the soil moisture all throughout being supplied by irrigation.

Of the crop sown in February, none of the plants made favourable growth. Irrigation was resorted to very frequently and in some cases soil moisture was carried as high as 40 per cent. The amount of prussic acid found on the date of the first analysis remained sensibly constant till the middle of April, after which it rapidly disappeared.

TABLE I.

Date	HCN	Date	HCN
	Per cent.		Per cent.
March 11	0·096	April 10	0·087
„ 18	0·117	„ 25	0·023
„ 25	0·095		
„ 30	0·103	May 5	0·004

This fairly constant quantity of prussic acid, which showed no tendency to diminish until after the middle of April, although an abundance of soil moisture was supplied, must have been due to a suspension of enzymic activity and to a deficiency of protoplasmic function as long as the temperature was low. With the increase of warmth, accompanied by one or two showers of rain, the growth became rapid, the enzymic action increased and this was followed by an almost total disappearance of the poison. This confirms Vinal and Reed's suggestions[1] as to the probable cause of slowing up of growth at low temperatures.

The next crop was planted at the end of March in three sets of plots which received different amounts of irrigation water. The moisture content of the plots was kept at amounts varying from 6 and 22 per cent. There were dry west winds blowing at the time and it was very difficult to maintain an evenness of moisture conditions, at any rate in the surface soil, for any length of time. Very frequent and prolonged irrigations had to be resorted to and attempts were made to see that the percentage of moisture, though

[1] *Jour. Agri. Res.*, XIV, No. 2.

not rigorously kept constant, did not fluctuate between wide limits from day to day. No very considerable difference was found in the amounts of prussic acid in the plants growing in the different plots, so that, under the conditions then obtaining, a difference between 6 and 22 per cent. in the amounts of soil moisture made no appreciable difference in the hydrocyanic acid content of the plants. This can be seen from Table II.

TABLE II.

Average moisture content in the soil	HCN per cent. on different dates			
	25–3–19	1–4–19	8–4–19	23–4–19
20 — 22 per cent.	0·193	0·143	0·051	0·033
13 — 15 "	0·209	0·169	0·076	0·064
6 — 9 "	0·181	0·232	0·086	0·057

The crops never made good growth. Even on the 23rd of April when the hydrocyanic acid reached a pretty low figure, the biggest of the plants did not weigh more than 20 grm. The very high temperature at this time of the year, as well as the low atmospheric humidity, evidently retarded the growth. Still the amounts of prussic acid, great at first, went on diminishing though at a not conveniently rapid rate. The difference between the above results and those obtained from the earlier sowings in February indicates that a high temperature is probably one of the factors determining a more rapid disappearance of prussic acid from the plant, even though the plant itself may be making a very unfavourable growth.

Sowings made in the month of May, when the humidity conditions also have greatly changed, produce plants in which the disappearance of the acid is even more rapid and the plant seldom contains anything more than a negligible quantity when about six weeks old.

Temperature is therefore obviously a factor which has much to do in stimulating enzymic action and causing disappearance of the glucoside even when the growth of the plant is retarded. This disappearance is even more rapid when the humidity is also high.

The stunting of a crop, except at a low temperature, is not always an indication of the crop's possessing a high dhurrin content.

Appreciable differences were also observed in the amounts of hydrocyanic acid obtained from the samples of plants collected early in the morning and those late in the afternoon. These differences, which were very prominent in the early stages of the growth, tended to diminish with the age of the crop and would probably vanish after a time.

TABLE III.

Showing the variation in the HCN content between day and night.

Plot No.	Date	Morning	Evening
3	22-3-20	0·105	0·073
	30-3-20	0·069	0·040
	31-3-20	0·068	0·044
	9-4-20	0·036	0·036
4	22-3-20	0·130	0·107
	30-3-20	0·116	0·092
	31-3-20	0·124	0·107
	9-4-20	0·069	0·054
6	22-3-20	0·125	0·094
	30-3-20	0·105	0·077
	31-3-20	0·107	0·081
	9-4-20	0·056	0·048
2	23-3-20	0·056	0·044
	3-4-20	0·045	0·039
5	23-3-20	0·051	0·040
	3-4-20	0·044	0·048

It has already been said that Willaman and West found no constant variations between the morning and the evening samples. On the other hand Menaul and Dowell[1] found similar differences in the case of Sudan grass which behaves similarly to *jowar* in respect of cyanogenesis and like it shows the greatest amount of hydrocyanic acid in very young stages, the quantity diminishing as the plant advances towards maturity. It is possible that Willaman and West's observations were taken when the differences had disappeared.

The amount of hydrocyanic acid found in the plant at any time represents the balance of the quantity produced and that used up for the growth. The differences noticed in the morning and the

[1] *Jour. Agri. Res.*, XVIII, No. 8, p. 448.

evening samples might be due to the differences in the rate of production of the glucoside or in the rate of its breaking up and utilization for the purposes of the plant. If the temperature and humidity were the only factors to be considered in this case, it might be said that the higher temperature during the day would cause a more rapid disappearance of the glucoside. But sunlight might also be an important factor which would influence both the rate of production and of diminution. In order to observe if different degrees of sunlight have any influence in this respect, plants were grown in pots and kept in different degrees of shade. The average height of the plants was the same both in the shade and in sunlight, but those in sunlight were sensibly heavier than those in the shade and the hydrocyanic acid content of the former was also greater.

TABLE IV.

Showing the amounts of HCN found in plants receiving different amounts of sunlight.

Date	Plants in sunlight or shade	Height	Average of a plant in grm. weight	HCN per cent.
16th May	Sunlight	18 — 20 c.m.	0·155	0·0063
"	Shade	Do.	0·146	0·0021
19th May	Sunlight	20 — 25 c.m.	0·106	0·0060
"	Shade	Do.	0·089	0·0026
20th May	Sunlight	25 — 40 c.m.	0·480	0·0015
"	Shade	25 — 30 c.m.	0·362	traces

This would imply a greater rate of production in the plants exposed directly to the sun. The natural inference, therefore, is that during the day there is a greater quantity of dhurrin produced ; this, however, is balanced by a quicker breaking up, so that the net amount present at the end of the day is less than what is found at the end of the night.

Lastly, it was found that plants which were dying in the fields for want of water contained no trace of the cyanide. It was also noticed that plants removed while green, dried and then examined some weeks after, were entirely free from the glucoside. Drying of the plants has been known to remove the hydrocyanic acid largely, but the evidence as to the extent of the removal has been conflicting.

Dowell's experiments[1] are the latest records on the subject, and he found that, during the process of drying, approximately three-fourths of the amount of the hydrocyanic acid is removed, the amount retained at any time depending on the rapidity with which the drying had been carried on. In India, during the excessive humid atmosphere of the rainy season, sun drying is not a rapid process and this may be an explanation of why dried plants have been found to have lost all trace of the acid. Similarly, with dying plants still standing in the fields, drying is necessarily a slow process and dissipation of the hydrocyanic acid at that stage is great. In order, however, that drying may proceed, the temperature of the plant must be raised so that it is to be expected that in such a case, on account of accelerated action of the enzyme, a much less amount of hydrocyanic acid will be obtained from the plant, provided that the temperature has not been raised too high to stop all enzymic action. Similarly, in the case of dying plants where the rate and the amount of transpiration has diminished, the temperature will increase with increased dissipation of the acid as a result. In the case of too rapid drying, the temperature has to be raised considerably resulting often in the destruction of the enzyme, thus preventing further liberation and escape of the hydrocyanic acid. It is owing to a similar reason that continued exposure of a crop of *jowar* to too high a temperature (higher than 92° or 93° F. according to Vinal and Reed)[2] retards its growth by rendering inoperative the activity of the enzyme.

[1] *Jour. Agri. Res.*, XVI, No. 7, pp. 175–181.
[2] *Jour. Agri. Res.*, XII, No. 2.

A DISCOVERY: *ANDROPOGON PURPUREO-SERICEUS* AND ITS IMPORTANCE IN THE IMPROVEMENT OF GRAZING AREAS IN THE BOMBAY DECCAN.*

BY

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THE writer uses the term "discovery," as the importance of this species is not mentioned in any of the previous literature on Indian grasses. No mention is made of its uses by Cook in his Bombay Flora. Lisboa, writing of this grass, remarks : "Uses not known" (*Bombay Grasses and Their Uses*, page 78). In 1912, along with some wild fodder grasses and leguminous plants, *Andropogon purpureo-sericeus* was also separately tested in a one *guntha* (1/40th of an acre) plot of medium black soil of about three feet in depth in the Ganeshkhind Botanical Garden, Kirkee, near Poona. It grew well to the height of five feet and gave a calculated outturn of 6,680 lb. semi-dry grass per acre in December.

In 1913, the self-sown seeds in the same plot produced a good crop and gave two cuttings, one in September and another in December, with the total calculated yield of 8,920 lb. green grass per acre. The green stuff was fed to cattle and eaten by them with relish.

In 1915, this species was also tried on a poor soil of red colour of laterite at Tegur (District Dharwar) and found to be thriving well.

Nothing particular was observed during these years. But when in 1916, the seeds of *Andropogon purpureo-sericeus* were indiscriminately mixed with those of other species, and sown,

* Paper read at the Eighth Indian Science Congress, Calcutta, 1921.

ANDROPOGON PURPUREO-SERICEUS.

after proper cultivation of the land, in three plots of good, medium, and poor soil in the Government House compound, Ganeshkhind, it struck everybody that visited the plots that *Andropogon purpureo-sericeus* grew well and was dominant with its thick growth in all the plots. Not only this, but also *Andropogon contortus* which was prevalent in all the plots before they were treated was far less common. The grass was cut in December, and the first two plots of good and medium soil gave each 16,000 lb. and the third of poor soil 5,000 lb. green grass per acre. The green stuff was offered to bullocks and eaten by them with relish.

After a month and a half a second growth was produced and allowed to self-seed for the ensuing year.

In the beginning of June 1917 the seeds of the following species were broadcasted :—Thirty-six and seventeen pounds of seeds of the mixture of *Andropogon caricosus*, *Andropogon monticola*, Sudan grass and *Tricholeana rosea* for good and medium soils, respectively, and 7 lb. of the mixture of *Andropogon caricosus* and *Chloris barbata* for the poor soil. The seeds germinated well and produced a good crop. This year (1917) it was observed that *Andropogon purpureo-sericeus* was less common; *Andropogon contortus*, the original species, was rare; and the introduced perennial species, *viz.*, *Andropogon monticola*, *Andropogon caricosus* and *Andropogon pertusus* were increasing in the plots.

In 1918, no fresh seeds were sown, and the following observations were made during the year :—(*a*) The perennial species mentioned above grew well and looked more prominent. (*b*) *Andropogon purpureo-sericeus* entirely disappeared from the plots to our great surprise. (*c*) *Andropogon contortus* was found only scattered on poor soil.

As a result of these experiments on three plots for three continuous years, the following facts were noted :—

(1) *Andropogon purpureo-sericeus* grew well and was dominant on good, medium and poor soils.

(2) The original hardy and inferior grass, *viz.*, *Andropogon contortus*, which was dominant before, was suppressed.

(3) It acted as a nurse crop for the perennial grasses which are generally slow to establish, since it entirely disappeared from the plots when the latter were more dominant.

(4) It provided a good supply of green fodder in September either for immediate use or for turning into silage.

These facts were further tested and confirmed by the following experiments.

EXPERIMENT No. 1.

An area measuring about 2½ acres, and having the soil varying from two to six inches, slightly reddish in colour originated from trap rock, thus fairly representing the poor land of the Deccan, was selected for the experiment at the Government House compound in the beginning of 1918. *Andropogon contortus* was dominant on the whole area.

The grass was cut and the land cultivated before the seeds of the mixture of the following species were broadcasted in the beginning of July :—

	lb.
Andropogon purpureo-sericeus	100
Anthesteria ciliata	50
Thelepogon elegans	50
Andropogon caricosus	50
Iseilema wightii	30
Ischæmum sulcatum } ,, *laxum* }	20

Seeds germinated well but the seedlings were affected by the scanty rains. Many seedlings succumbed and there were many gaps in the plot, so the area was again harrowed and a fresh lot of 230 lb. of seeds of the mixture used above was sown in August. This time, too, the seedlings simply dragged on owing to the insufficiency of moisture throughout the season. The seedlings that survived made a fair growth, and *Andropogon purpureo-sericeus* was found to be dominant, and *Andropogon contortus* less common in the plot. The grass was cut in November when most of the seeds dropped down and the yield amounted to 800 lb. dry per acre. Considering the abnormal condition of the year, the total yield per acre is not bad.

In 1919, 64 lb. of seeds of the mixture of *Andropogon caricosus* (44 lb.) and *Ischæmum sulcatum* and *Ischæmum laxum* (20 lb.) were sown in the beginning of June. The season was favourable, so the seedlings came up all right and grew excellent.

This year (1920) again it was observed that *Andropogon purpureo-sericeus* was dominant and *Andropogon contortus* was still less common.

It is gratifying to note here that the plot was visited by the Deputy Directors of the Bombay Presidency, as well as by private gentlemen, who were pleased to see a good crop of grass on poor soil which cannot grow economic crops, and indented for the supply of seeds of *Andropogon purpureo-sericeus* for further trial on poor soils.

The grass was harvested late in November when most of the seeds dropped down ; the yield was 1,800 lb. dry per acre.

It was reported by the Manager of the Civil Dairy, Poona, in his letter dated 31st May, 1920, addressed to the writer, that *Andropogon purpureo-sericeus* even in its dry stage was eaten by the dairy cows which maintained the milk yield in the absence of *jowar* (*A. Sorghum*) stalks in May, while *Andropogon contortus* was not touched by them, a fact which proves the superiority of this species as a fodder over *Andropogon contortus.*

In order roughly to determine the extent to which *Andropogon purpureo-sericeus* was found and *Andropogon contortus* suppressed in the experimental area, the stuff was cut from two small plots measuring ten feet by ten feet and the different species weighed separately. The following table shows the composition and the weight of the species.

	Plot I	Plot II
	Wt. lb.	Wt. lb.
Andropogon purpureo-sericeus	12	10
Ischæmum sulcatum	8	5
Andropogon contortus	3	nil
Andropogon pumilus	4	nil

The above table clearly shows the dominance of *Andropogon purpureo-sericeus* and the elimination of *Andropogon contortus* in the poor soil in support of the previous observations.

In 1920, no fresh seeds were added ; the fallen seeds of the last year germinated well. When the seedlings were about two weeks old, they were first affected by a draught of a fortnight, and then the timely rains revived them. They were just recovering from the previous shock when they were again exposed a second time to a draught which lasted for about a month, thus *Andropogon purpureo-sericeus* even in its young stage passed through two critical periods. Still it grew fairly well up to two feet in height and was dominant in the area. This fact goes to prove the draught-resisting power of *Andropogon purpureo-sericeus* even in its young stage. This fact was further tested by actually counting the number of seedlings from a measure of three feet by three feet in the experimental area affected by the draught and by recounting those that survived. The following shows the details.

Two thousand four hundred and eighty seedlings were found affected on 1st September, 1920. Of these, 2,088 were found survived and flowered on 11th October, 1920. Thus the percentage comes to more than 84.

Andropogon contortus was entirely absent where *Andropogon purpureo-sericeus* had made a thick growth.

Stumps of *Ischæmum laxum* were more visible in a greater part of the area. Plants of *Andropogon caricosus* began to appear though in scattered condition.

The results of this experiment for three years may be summed up as below :—

(*a*) *Andropogon purpureo-sericeus* grew well even on poor soil and yielded a fairly good quantity of fodder in September.

(*b*) It suppressed the inferior species, *viz.*, *Andropogon contortus*, which was the main grass on the poor land.

(*c*) It itself proved a hardy and draught-resisting species.

(*d*) It was found a better fodder even in its dry stage than *Andropogon contortus* in the hot weather by the dairy cows which maintained the milk yield.

Experiment No. 2.

In 1919, four ounces of seeds of each of the following species were mixed together and sown broadcast after proper cultivation in the beginning of June in a small plot (six feet by six feet) of poor soil in the Government House compound, Ganeshkhind.

Annuals. *Andropogon purpureo-sericeus*, *Apluda varia*, *Ischæmum sulcatum*, *Thelepogon elegans*, *Anthesteria ciliata*.

Perennials. *Andropogon monticola*, *Cenchrus biflorus*, *Chloris barbata*.

The land had *Andropogon contortus* as its chief grass, and it represented the common poor land of the Deccan. The seeds germinated well and the seedlings grew all right ; the mixed grasses were cut in October. The following table shows the composition of different grasses in weight and also the height to which they grew.

Species	Wt.	Ht.
	lb.	ft.
Andropogon purpureo-sericeus	13	6
Anthesteria ciliata	4	5
Apluda varia	2	4
Ischæmum sulcatum	1	2
Thelepogon elegans	1	1

From the above figures it is clear that *Andropogon purpureo-sericeus* grows better and is dominant as was previously experienced.

In 1920, the self-sown seeds produced a good crop of *Andropogon purpureo-sericeus* in September in spite of scanty and irregular rainfall. This goes to support the statement that *Andropogon purpureo-sericeus* is draught-resistant.

Experiment No. 3.

In 1919, at Athani (Belgaum District) in a *kuran* (grazing area) fairly representing the poor land and over-grown with *Andropogon contortus*, a plot of four *gunthas* was cultivated and

grown with the following mixture at the rate of 75 lb. per acre in the beginning of July.

	lb.
Andropogon purpureo-sericeus	30
Thelepogon elegans	20
Apluda varia	10
Anthesteria ciliata	5
Andropogon caricosus	5
Ischæmum sulcatum	5

The seedlings appeared all right, but were soon checked by a long break that lasted for a month in August. Good showers in September put a new life into the drying seedlings and saved the situation.

The plot was observed in the beginning of November by Dr. Burns, Economic Botanist, accompanied by the writer, and it was found that in the reseeded plot *Andropogon contortus* was rare, and *Andropogon purpureo-sericeus*, *Apluda varia*, *Anthesteria ciliata* and *Thelepogon elegans* were common and made a fair growth.

The results of this experiment are in support of the statements made regarding *Andropogon purpureo-sericeus*, *viz.*, (1) that *Andropogon purpureo-sericeus* in spite of scanty rains grows well on poor soil and is dominant and (2) that *Andropogon contortus* is suppressed.

Experiment No. 4.

The Superintendent, Kopergaon Farm (Ahmednagar District), states in his letter addressed to the writer, dated 13th October, 1920: "Owing to insufficient rains, the plot of Marvel (*Andropogon annulatus*) grass kept on rain water only failed to give any outturn. The growth of it is so very poor that it is not worth while cutting; the gaps are still existing.

"This year (1920) another plot measuring 10 *gunthas*, which was sown with Kolhapur grass (*Andropogon purpureo-sericeus*), has thrived very well in salt affected area; the height of the grass was four feet to five feet. It has given the yield of 3,688 lb. per acre (nearly dry weight) as it was cut when the seed was ripe."

Messrs. Burns and Chakradeo in their paper on the grass experiment at Kalas submitted to this Congress have shown that

there also *Andropogon purpureo-sericeus* maintained its character as a draught-resistant and heavy yielding grass.

Summary.

(1) *Andropogon purpureo-sericeus,* a wild indigenous fodder grass, is suitable for poor land, grows tall, quickly, and yields by itself up to 5,000 lb. green grass per acre, hence its usefulness for silage.

(2) It suppresses *Andropogon contortus* which is dominant on the vast area of poor land of the Bombay Deccan.

(3) Cattle like it better even in its dry stage in the hot weather than *Andropogon contortus,* thus proving its superiority over the latter.

(4) It resists draught conditions to a great extent.

(5) It acts as a nurse crop to perennial grasses.

(6) It is a pioneer grass in the artificial reseeding of grazing areas.

Statement showing the yield of Andropogon purpureo-sericeus *for several years.*

Year	Area	Soil	Calculated yield per acre	Green or dry	Remarks	
			lb.			
1912	1 guntha	Medium black soil	3,340	Dry	Pure	Good year
1913	1 guntha	Do.	8,920	Green	Do.	Do.
1916	1 acre	Black soil	16,000	Do.	Mixed with other good grasses but in slight degree	Do.
1916	½ acre	Medium black soil	16,000	Do.	Do.	Do.
1916	9 gunthas	Poor soil	5,000	Do.	Do.	Do.
1918	2½ acres	Do.	800	Dry	Do.	A bad y ar
1919	2½ acres	Do.	1,800	Do.	Do.	A good year
1920	10 gunthas	Deep black soil	3,688	Nearly dry	Pure	A bad year

AGRICULTURE IN THE SHAN STATES.

WITH SPECIAL REFERENCE TO THE SYSTEM KNOWN AS "TAUNGYA" CULTIVATION.

BY

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(Concluded from Vol. XVI, Pt. III, p. 264.)

THE "TAUNGYA" PROBLEM AND ITS SOLUTION.

THE ultimate aim of all "taungya" investigations has been to bring the land under permanent cultivation—to put a stop to this destructive method of agriculture and so to induce the people to settle down on holdings of reasonable size. If this end could be achieved the benefits to be derived by the country are incalculable.

It is obvious that repeated burning or heating of the surface Soil cannot be regarded as practicable. Apart from the question of waste the supply of wood fuel has already almost given out in some places, *e.g.*, the Myèlat and South Hsenwi, and will quickly disappear elsewhere as the population increases. So long as large areas well covered with jungle are available, heating the soil is not a very expensive process to the cultivator, but when fuel has to be collected and carried the cost of the operation is very heavy, whilst to burn cattle manure, laboriously collected from the roads and fields, is the most wasteful if not the most expensive method of all.

Some method of soil treatment other than heating or burning must therefore be found. The results of some practical field

experiments carried out at Yawnghwe and Hsumhsai inaicate a simple and practical solution of the problem, and a few typical extracts from the considerable numbers of results bearing on the problem are given below.

LIMING.

We have already mentioned that the soil lacks lime and organic matter. The practical effects of liming are shown in the following tabular extracts of experimental results. Lime was applied once only at the rate of 6,000 lb. per acre, and up to the present three crops have been taken off the land.

The effect of liming.

(Outturns in lb. per acre.)

Crop	1ST YEAR			2ND YEAR			3RD YEAR			AVERAGE INCREASE		REMARKS
	Not limed	Limed	Increase due to lime	Not limed	Limed	Increase due to lime	Not limed	Limed	Increase due to lime	Per acre	Per cent.	
Wheat	292	617	325*	480	720	240	276	567	291†	273	120	*Average of 6 series of plots. †Average of 7 series of plots.
Groundnuts	700	1,090	390	160	700	540	1,080	3,260	2,180	703	108	
Linseed	360	665	305	380	660	280	240	410	170	251	76	
Pèsingon	315	660	345	250	665	415	1,280	1,670	390	383	62	
Pèyin	710	955	245	250	390	140	270	500	230	205	50	
Sadawpè	80	190	110	600	940	340	300	840	540	209	63	
Gram	330	1,430	1,100	350	610	260	540	1,030	490	616	151	
Potatoes							4,480	7,040	2,560	2,560	57	Average of 2 experiments.

The above results were obtained on land that had been cultivated without previous burning for one year; but on an old "taungya" that had been lately abandoned the response was even greater. The single dressing of lime in this case was 5,000 lb. per acre and the figures for one year only (plots one-twentieth of an acre in area) are available.

Lime on old "taungya" land.

(Outturns in lb. per acre at Hsumhsai.)

Crop	Unlimed strip	Limed strip	Increase due to liming	Increase per cent.	REMARKS
Maize (Bur.)	nil	3,440	3,440	In fi..	Dried cobs
Do. (Shan)	nil	2,540	2,540	Do.	Do.
P. byugalè	330	530	200	60	*Phaseolus lunatus.*
Pèsingon	900	2,080	1,180	131	*Cajanus indicus.*
Pèyin	470	2,130	1,660	353	*Phaseolus calcaratus.*
Gram	200	420	220	110	*Cicer arietinum*
Buckwheat	520	1,640	1,120	215	
Sadawpè	320	960	640	200	*Pisum sativum.*
Linseed	70	680	610	870	

The figures of a single trial should, of course, be accepted with caution, but the differences are so great and the conditions of the experiment in this case are such that the evidence is conclusive.

A wide variety of crops has been tested over several years and not a single one but has responded in a high degree to the dose of lime. From the former of the above tables it will be seen that the dressing has not diminished in effect after three years. The experiments are still going on, though the high value of lime is considered to be proved.

The action of lime. Whilst we know what the effect of lime is on crop production, without the researches of chemists and biologists on the spot we can only surmise how this effect is brought about. The well-known actions of lime are its effect on the physical condition of the soil, the chemical decomposition of some of the soil organic matter and, where very deficient, the direct supply of a certain amount as plant food ; but it has been shown by Hutchinson and MacLennan[1] that calcium oxide (caustic lime)—but not calcium carbonate, *i.e.*, limestone or chalk—if applied in sufficient quantities,

[1] "The Effect of Lime on Certain Soils." *Jour. Agri. Sci.*, VI, pp. 302–321.
"Lime Requirements of Certain Soils." *Jour. Agri. Sci.*, VII, pp. 75–104.

exercises a partial sterilization effect similar to that shown by heat or by other sterilizing agents. There occurs a sudden initial decrease and a subsequent increase in the numbers of bacteria present in the soil, and the larger forms of protozoa are killed or checked. The caustic lime also causes chemical decomposition of some of the organic matter of the soil and the formation of ammonia, which is followed, when bacterial growth recommences, by a large increase in the rate of ammonia production. The same investigators also showed that light soils poor in organic matter and in calcium carbonate (such as are our "taungya" lands) reacted sharply with a small application of lime, which was not the case with richer soils containing more organic matter or more carbonate.

Since the effects on crop production of heating and of liming "taungya" soils are very much the same, it seems probable that the lime here owes its efficacy in no small degree to its power as a sterilizing agent. But the effects of heating the soil generally disappear after a lapse of two or three years, whilst it has been shown above that there is no diminution after liming during a period of three years. It remains to be seen how long the dressing of lime will continue to act, but agricultural experience teaches us that it continues for a long time and it seems probable that liming will have a more durable effect than heating.

As for the magnitude of the effects, owing to the difficulties of measuring the amount of heat applied in a field experiment, it requires elaborate series of laboratory experiments to determine how much caustic lime is equivalent to a given amount of heat or a given quantity of fuel consumed. The small dressings of lime applied were taken as being well within the limits of practical agriculture, and these doses have given better results in point of yields than the ordinary operation of "taungya" burning has given.

Manuring.

All the soils except those of the valley bottoms are very deficient in organic matter and, as would be expected, applications of organic manures have very marked effects. Cattle manure is scarce and the small dressings have been regulated by the amount

usually made use of by the local cultivator, *viz.*, (about) 6,000 lb. only of moderately dry material per acre. This quantity was applied in the experiments, but as the local custom is to burn the manure in order to heat the soil—heating being regarded as of primary importance—this method has been tested alongside the direct application for the past three years. The following results obtained on an average piece of "taungya" land, not previously manured or planted with potatoes, are typical of the whole. As it is a feasible practice to follow a crop of potatoes by one of wheat the same year this is what has been generally done on the farm; but it is a practice not yet known to the cultivator.

Manuring of red upland "taungya".

Year	Potatoes			Wheat (Pusa 6)	Remarks
	Planting	Manuring	Yield of tubers	Yield of grain	
			lb. per acre	lb. per acre	
1919-20	In drills	Manure unburnt	9,620	1,260	
	Do.	Manure burnt	6,960	900	Wheat damaged by hares.
	Do.	No manure	2,800	nil	Wheat failed.
	Local method (Hills)	Manure unburnt	4,000	660	Wheat damaged by hares.
	Do.	Manure burnt	3,540	1,000	
1918-19	In drills	Manure unburnt	6,320		
	Do.	Manure burnt	5,040		
	Local method	Manure burnt	2,560		

In every case so far tried the benefit to be derived from unburnt manure has proved to be greater than that brought about by burning an equal quantity of manure in the soil, showing that the organic matter and manurial ingredients supplied by the manure are of greater value than the heat it will produce and that the local practice of using manure to heat the soil is very wasteful. Incidentally it is shown that the drill method of planting potatoes gives much better results than the local method. This method is now being introduced among cultivators.

The above results were all obtained without the aid of lime: the organic matter and nitrogen supplied by the manure on the one hand and the nitrogen produced by heating on the other remedied the most serious defects of the "taungya" land which would ordinarily have been abandoned. But with the assistance of a dressing of lime equally striking results were obtained, though the lime (5,000 lb. per acre) had been applied two and a half years previously. The land was a poor piece of "taungya" which had been cultivated for three years and potatoes were followed by wheat the same year.

Lime and manure on "taungya" land, 1919-20.

Manuring	Lime	POTATOES	WHEAT (PUSA 4)
		Yield of tubers	Yield of grain
		lb. per acre	lb. per acre
Cattle manure	Limed in 1917	8,780	1,060
Do.	Not limed	6,160	520
No manure	Limed in 1917	5,300	390
Do.	Not limed	2,800	nil

It should be mentioned in this connection that the average acre yields of potatoes and wheat obtained by cultivators are about 1¼ tons and 375 lb. respectively—and not from the same piece of land; whereas on the Yawnghwe farm (even by the very light manuring above mentioned) it has been found quite easy to raise 4½ tons of potatoes and nearly one ton of wheat from the same acre. Upwards of 5 tons per acre of potatoes have been raised on "taungya" land and this was followed by 920 lb. of wheat, but the best yields of potatoes have not been followed by the highest outturns of wheat. After a late two-ton crop of potatoes Federation and Pusa 4 wheats yielded 2,520 and 2,600 lb. per acre, respectively, on a good loam (not upland "taungya").

GREEN-MANURING.

To supply the deficiency in organic matter the quantity of cattle manure available is wholly inadequate and other means

will have to be found. Considerable quantities might be provided by the abundance, in many places, of succulent jungle growth, but its application is troublesome and not likely to become a popular practice. On the other hand, green crops will grow rapidly and luxuriantly and they can be very easily dealt with. The chief difficulty is to obtain seed, but as several locally grown crops are excellent for the purpose this difficulty can be overcome.

The average outturn of wheat from 14 green-manured plots (over a period of three years) has been 744 lb. as compared with 413 lb. of grain per acre from the controls, and many of the green manure crops were very light, owing to the difficulty of obtaining a good stand where no lime had been applied. One of the best green manure crops has proved to be a common mucuna (known as "gwe-nge"), but sann-hemp ("pikesan"), "pèyin" (*Phaseolus calcaratus*) and others have also done very well. They grow with great rapidity where the soil has been dressed with lime, but they frequently fail where this treatment has not been given; and consequently trials of green manures with and without lime have resolved themselves into tests of heavy and light crops of green manure. The addition of extra material to the non-limed plots has not been practised.

To a very considerable extent green-manuring can be made to supply the lack of cattle manure, and these manures not only supply available nitrogen (or ammonia) equivalent to that which, in the ordinary course of "taungya" cultivation, is produced by heat but they add much needed organic matter for future use—to be acted upon by the soil bacteria and gradually converted into further supplies of plant food. The effect is therefore likely to be much more lasting than that of burning which, on the contrary, tends to deplete the soil of the little organic matter it has gathered. Whether this is actually the case the experiments have not yet proceeded far enough to determine with certainty, but indications point in that direction which is also what agricultural experience would teach. The presence of lime, or the application of heat, would no doubt accelerate decomposition of the manure; so that, whilst the

immediate effects would be greater, as has already been found to be the case, the after effects may not be so lasting.

Weeds and erosion.

Weeds and erosion are two of the worst enemies of the "taungya" cultivator who is often forced to abandon his "taungya" early on their account. A green manure crop sown early during the rainy season cannot only be ploughed down in good time for a cold weather crop of wheat, beans, etc., but it will also serve as a protection against these enemies. Weeds which often take complete possession of the land during the rains are entirely choked out by a good crop of "pikesan" or "pèyin" and the land is left in a clean state. The greatest erosion which takes place during the heavy storms of June to August may be greatly checked by a thick standing crop. Thus a green manure crop sown at the right season may here serve a triple purpose.

Erosion may be entirely prevented, on all but very steep hillsides, by adopting proper methods of ploughing along the contours instead of up and down the hill, and by adopting the very simple preventive measure of leaving small contour drains or furrows bordered by narrow strips of unploughed land. Since this method was started on the hillsides at Yawnghwe no trouble whatever has been experienced from scouring which previously caused much destruction. The small drains are not more than 6 inches wide and 4 or 5 inches deep (they are started as an ordinary plough furrow) with a narrow unploughed strip of 10 or 12 inches on each side. They are made to follow the contours fairly accurately and the distance apart varies with the slope; on a gentle slope they may be wide apart but on a steep slope they must be closer together. By this means each strip of land deals with the rain-water falling on it only and any excess of surface water is unable to gather enough volume or velocity to do damage before it is arrested by the furrow. More water is absorbed by the soil if the latter is well cultivated, and there is less run-off. If the drains are made permanent, terraces are gradually formed between them without the heavy labour of

levelling which would be an impossible task in these regions where labour is scarce.

PERMANENT CULTIVATION.

From the results briefly sketched above it will be seen that there is no reason why the "taungya" lands of these vast areas should not be brought under a permanent system of agriculture.

There are two ready substitutes for the heat now being so laboriously applied as a remedy to our "taungya" soils, *viz.*, lime and organic manures, small dressings of either of which have greater effects on immediate crop production and seem to be more lasting in their power than an ordinary "taungya" burning. But whilst lime, by using up the little nitrogenous material present in the soil, tends towards exhaustion in the same way as heat does, organic manures have the opposite effect. The one causes the production of nitrogenous plant food, the other supplies it (in addition no doubt to aiding its production from substances already in the soil); but, as pointed out above, lime in the soil is necessary also for the production of green manures where cattle manure is scarce, and it is not difficult to see how a combination of these two "remedies" may go a long way in the desired direction. It may be argued that concentrated nitrogenous manures would supply the deficiency, but as these are hopelessly costly by the time they reach these tracts there seems to be little use in testing them at present.

Liming, manuring and good cultivation, combined with proper systems of rotation of crops, can make continuous cultivation much more profitable than the present methods of shifting from place to place. At Yawnghwe, upland red soil which has been under continuous cultivation for six years and which has not been burnt is still giving profitable outturns—in fact, the yields are gradually improving under the methods outlined above.

Liming is not absolutely necessary in all places but it is very beneficial, and as limestone is almost everywhere plentiful there appears to be no reason why it should not be universally practised. It seems to be more effectual than burning and is not likely to lead

to so rapid exhaustion. But if exhaustion is to be avoided organic manure in some form is essential. Yet a great deal may be done by good cultivation and rotations alone. Some of the older plots that have so far received neither lime nor manure still maintain their yields, though these are not very high, by good cultivation and rotations. There is no lack of suitable local crops for the purpose, *e.g.*, gram, groundnuts, " pèyin " (*Phaseolus calcaratus*), " sadawpè " (*Pisum sativum*), several kinds of valuable " haricot " beans (*Phaseolus vulgaris*) and several other leguminous crops are all suitable for rotations in which wheat and potatoes figure as the main crops.

Agricultural possibilities.

There are few countries with such natural advantages for agriculture or with such future possibilities as the Shan States. Besides tropical crops, a very large number of European crops may be grown to perfection, and this applies to fruit and vegetables as well as to the ordinary " field " crops. Better means of communication and of transport for produce are the crying needs and, given these, agriculture is bound to prosper, but simultaneously with the provision of these better methods of cultivation should be taught. The cultivator has already shown that he is willing to learn and to adopt better methods when demonstrated to him, and the crop material at the disposal of the scientist or experimentalist is extensive, varied and full of possibilities.

CROSS-FERTILIZATION AND STERILITY IN COTTON.

II.

BY

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In the previous article[1] it was pointed out that continued self-fertilization for a certain number of years does not encourage sterility in cotton, at any rate in two pure strains, one belonging to *G. herbaceum* and another to *G. neglectum.* It has also been found during this year that the same holds good for one or more strains of Dharwar-American cotton. This, however, does not prove definitely that self-fertilization is not the cause or one of the causes of sterility in cotton. Other cottons may behave differently, and, moreover, the same strains which do not show any increase in sterility may do so if subject to selfing for a longer period. But this is also no sufficient reason to condemn self-fertilization as a ruinous thing. Natural crossing takes place more or less in all cottons, and if we do not take sufficient precautions against it, our special varieties and strains are sure to run out and be lost to us in no time. All such cottons, therefore, should be selfed if they are to be maintained pure, and this should continue as long as no harm results from it.

The cotton plant has some attraction for the cross-fertilizing insects, principally the honey bee, and these are in all probability valuable accessories. But we do not know what definite service they render to the plant. Unfortunately we have no cotton which is almost completely exhausted from continuous self-fertilization so

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[1] *Agri. Jour. India*, XVI, Pt. I, p. 52.

that we can study the rejuvenescent influence of crossing on it. Crossing very often gives increased vigour to the hybrid plants. This, in certain crosses at least, is due to the dominant nature of the F_1 generation. If a tall sparsely-branched cotton is crossed with a dwarf well-branched one, the resulting progeny is tall and well branched. In this case the tallness and branching habit are the two dominants which together produce the effect. In fact, the F_1 plants are not taller than the tall, nor more branched than the branching parent. Similarly the vigorous appearance may be produced by other dominants constituting larger leaves or bigger bolls. Cottons which are alike in all or most of their characters, however, do not show any improvement by crossing. We once made a large number of *inter se* crosses with the object of increasing the vigour but we found them to be in no way better. For the above reasons the beneficial influence of foreign pollen seems to be highly doubtful.

We have noticed three kinds of sterility in many Indian varieties of cotton growing at Dharwar and have studied the extent of each in two pure strains. These two are artificially crossed. Now, if self-fertilization is the cause of sterility and natural cross-fertilization which is occasionally taking place is a cure, our crossing should do us some good. The cross was accordingly examined for sterility, and it was found that the first form affecting the floral parts except the calyx was altogether absent in the parents and in all the generations of the cross during our period of observation. The second and third forms appeared to the same extent as the parents in the F_1 generation and to a greater extent in the F_2 and F_3 generations. We have not seen all anthers of a flower being sterile in the two parents, but a number of such flowers are noticed in the second and third generations. This clearly shows that crossing has not lessened the amount of sterility but on the contrary increased it in some generations.

The increase in sterility of any kind causes, in general, a corresponding decrease in yield. But we cannot judge the amount of sterility from the yield as the latter is also dependent on other factors. The *herbaceum* parent of our cross is a better yielder

than the *neglectum*. The bolls on the former are many and small, but on the latter few and big. In the F_1 generation the bolls are many as well as big, and consequently the yield is larger than that of the *herbaceum* strain. Anyhow the cross shows improvement as regards yield in the first generation. But this improvement is unfortunately temporary. In the very succeeding generation, the great majority of the plants fail to yield even as much as the *neglectum* parent, and the crop on the whole appears very unproductive. The same is true for the F_3 generation raised from the seed of good selected plants with the exception of few rows where the bearing is good and uniform. We thus see that, in the cross we are studying, the F_1 generation is stationary as regards sterility but there is a decided improvement as regards yield. The F_2 and F_3 generations show an increase in sterility and also a decrease in yield.

The cross is also interesting from another point of view. We have noticed only three kinds of sterility in the parents, but in the F_2 and F_3 generations a new form makes its appearance.

This is characterized by the peculiar dark colour of the leaves which makes its detection easy in the early stage. The leaves, however, do not curl or become diminutive as in the first kind, but become thick and somewhat brittle. The individuals thus affected grow 12 to 15 inches high and then their progress stops all at once. The stem and petioles thicken and even crack. The branching is very sparse. The buds on the central stalk remain dormant or produce short and thick side-growths. Most of these plants do not flower. They remain in the field till the advent of the hot weather when their leaves turn first yellow and then red, and they ultimately die. In some cases, however, few buds and flowers are seen, but they all fall. The plants are thus completely sterile and they die without producing any seed.

This new kind of sterility is not found to occur in the F_1 generation. In the F_2 generation about 7 per cent. of the individuals are sterile. In the F_3 generation the extent varies in different progeny rows. Some rows are completely free while

others are badly affected. The following statement gives an idea of the variation in the first 10 rows of that generation.

No. of progeny row	No. of plants in the row	No. of sterile plants	Percentage of sterility
1	94	7	7·5
2	109	1	9·1
3	95	4	4·2
4	44	1	2·2
5	74	7	9·5
6	78	16	20·5
7	88	0	0·0
8	93	15	16·1
9	100	9	9·0
10	61	0	0·0

We do not know the cause of this sterility, but from the abnormal colour of the leaf with which it is always associated, we can say that the colour-producing factors suffer in some way during the process of their redistribution and the leaf is incapable of performing its functions properly. The colour of the *herbaceum* leaf is yellowish green and that of *neglectum* dark green. The cross is more like *herbaceum* in the first generation. In the second generation there are many gradations, and we are not able to distinguish them well. The one with which we are concerned here shows that there is very little of yellow in it. The absence of this colour seems to be the cause of sterility by inducing the abnormities described above.

The sterile plants die without seeding. There is also no fear of their pollen being carried to other plants as they rarely flower. But still sterility may continue to appear in any proportion. Some prolific plants of the F_2 generation have thrown out their progeny, a large proportion of which is sterile. This shows that great care is necessary in selection. This sterility, however, is peculiar to the cross. We have made and examined a number of crosses mostly between *herbaceum* cottons but not come across with this or other new forms of sterility in any generation.

In conclusion, it may be stated that crossing does not cure sterility but on the contrary seems to encourage it to some extent as in the present case even by originating new forms not found in the parents.

Selected Articles

THE GROWTH OF THE SUGARCANE.*

BY

C. A. BARBER, C.I.E., Sc.D., F.L.S.

IX. ON TILLERING.

TILLERING is the term usually employed to indicate the amount of branching which occurs in a grass during its first, mainly underground, period of growth. On this will depend the number of upright shoots produced during its second and final flower producing period. Tillering does not necessarily mean the number of canes maturing at harvest, for, as we shall see, there are a number of factors which limit the plant's power to produce its maximum output: the control of these factors will make all the difference between good and bad planting. Given a piece of land and a certain variety of cane, we can obtain many or few canes, thin or thick ones, according to treatment. Tillering really means the inherent shooting capacity of the cane and this differs a good deal according to the variety and especially the group of cane grown.

Of the characters of a new seedling which we wish to bring into cultivation, tillering is one of the most important, and figures are always recorded of the number of matured canes produced in the first year's growth. But we only get an indication at first, and must grow it for several years before we can be certain that we have got the right figure. Often in the first year a seedling produces a very large number of branches but is disappointing later on, and the reverse may be the case. Of course much depends on treatment. For instance, when the first seedlings were obtained in India, they were treated with the greatest consideration and were planted in

* Reprinted from *Int. Sugar Jour.*, September 1920.

large pits filled with prepared earth, as no suitable land was available for planting them out. It is not surprising that some of them produced between one and two hundred well-matured canes. To judge the tillering capacity of a new cane or seedling we must not only approximate as closely as we can to normal field conditions but also grow at intervals in each plot some of the well-known local varieties with which it is wished to compare it: this has now become the routine practice on the Cane-breeding Station at Coimbatore; and, for fear that the unaccustomed energy of production from fertilized seed may be of influence, we prefer to grow the seedlings for several years under varying conditions before coming to a conclusion.

On examining a batch of seedlings from the same parents, it is at once obvious that they differ in tillering capacity; batches from different parents also vary, as do the parents themselves. We are driven to the conclusion that this is a fundamental character in the variety, just as the thickness, width of leaf, and the many other characters by which we distinguish them from one another. Perhaps the most important point to note, from the crop point of view, is that there seems to be a close relation between the natural thickness of a cane and the number of canes per clump. And, although both of these characters may be profoundly influenced by treatment, for instance by wider spacing, there appears to be an inherent tendency for thinner cane varieties to produce more canes per plant. Thus, thick tropical canes produce fewer branches than thin Indian ones, and the latter vary greatly, not only among themselves individually, but according to the group to which they belong. This is brought out in the figures obtained in the varietal plots at the Coimbatore farm, where the average number of canes per clump was calculated for each of the main groups of canes grown; the following were the averages during one year:—Mungo group (average of 32 varieties), 15·10; Nargori (13), 15·10; Brown Saretha (13), 14·00; Sunnabile (22), 12·55; Pansahi (17), 11·00; Green Saretha (10), 9·50. On examining the thickness of the canes in these groups we do not find any correlation between it and the number of canes per clump: thus Mungo and Pansahi are among

the thickest, and Nargori and Brown Sāretha are among the thinnest. But if we take the varieties in any one group we find some striking figures. The subjoined table is taken from a Memoir[1] by the author where the whole question of tillering is somewhat exhaustively studied. The details were drawn from a comparison of the two groups, Sunnabile and Saretha, and had nothing to do with the subject under discussion when the measurements were taken. The table includes all the varieties in each group which were examined at the time : the plants were grown together in adjacent plots under exactly the same conditions.

Saretha group			Sunnabile group		
Variety	Canes per clump	Thickness in cm.	Variety	Canes per clump	Thickness in cm.
Chin	29	1·5	Kaghze	20	1·6
Saretha (green) ..	28	1·7	Bansa	18	1·8
Khari	24	1·8	Sunnabile	17	1·9
Hullu Kabbu ..	22	1·9	Naanal	15	2·1
Ganda Cheni (poor) ..	16	2·0	Dhor (poor) ..	12	2·2
Average ..	24	1·8	Average ..	16	1·9

From these figures, we see that, in each variety, the tillering power varies more or less inversely with the average thickness of the cane. But another point is also brought out, namely, that for such comparisons we must confine ourselves to members of the same group : the Saretha group, judged by the few examples taken here, has a greater tillering power than the Sunnabile, for while the average numbers of canes per clump are 24 and 16 respectively, the average thickness of the cane is practically the same in the two groups. Saretha canes are usually thinner than those of the Sunnabile group, but independently of this the tillering power is greater. Tillering is one of the most striking characters which, taken as a whole, make up what we call the habit (or appearance)

[1] C. A. Barber. "Studies in Indian Sugarcane, No. 4. Tillering or underground branching." *Mem. Dept. Agri. India, Bot. Series,* X, 2, 1919.

of the plant, and the great groups of sugarcanes differ markedly in this respect. Another series of observations made in North India compares the thick tropical canes, the half thick intermediate forms, and the thin Indian canes, and the relative tillering power of these three groups was as 5 to 7 to 12 respectively: so, while we may accept as a general principle that in cultivated canes thickness and tillering power are inversely related, we must also be careful not to neglect the inherent characters of the groups.

When, however, we come to apply this knowledge, of the tillering power of different varieties of canes, to the number of canes reaped at harvest in the field, we are met with a number of difficulties and it will be necessary to consider these in some detail. There are a number of factors which limit the power of a cane variety to produce its full quota at crop time. In the first place there are a great many deaths during growth, especially in the stages when canes are beginning to form; then the distance apart of the canes and the general treatment have a very decided influence, and we must find out what are the causes of the influence of these factors and how we may try and control them. Roughly, the chief external influences on the tillering of canes are the light available, the moisture in the soil, the character of the soil, and the amount of manure applied.

Of these influences, there appears to be little doubt that light is most important. This is unfortunately the only part of the environment over which we have not control: there is so much light available for each square yard of land and we are powerless to increase it: we do not habitually grow canes under the shade of the trees which can be cut down. The physical effect of light upon a grass is to press it down, to check the growth in length of its upright shoots, and thus to divert its energy into branching. Full light thus helps tillering, but, in a closely planted field, once the available light on a given area is filled with cane shoots, all later arrivals are under a disadvantage, lead a struggling existence and often dwindle and die. The same effect is seen in a forest, for on the edges the trees are well proportioned and spreading while in its depths they are tall, slender, and thin, or if unable to reach the top remain stunted and unhealthy. It is always idle to judge of the

number of canes in a field by counting the number of shoots per clump in the outer plants.

Perhaps the deaths taking place in a cane field have received insufficient attention in the past : when all is said and done, they are not good for the plant and use up a great deal of energy which might be more usefully employed. Let us examine some of the figures that have been published. Stubbs in 1894-95 calculated, from a careful examination of the Purple and Striped Louisiana canes, that the deaths among shoots formed 58·9 per cent. of the whole output in 1894, and 56·9 per cent. in 1895. In Java, Muller Von Czernicki counted the shoots existing at different periods of growth in several varieties. In Cheribon there were 120–180 in the different plots at 60 days from planting but only 60–70 after 150 days. In J. 247 there were 160–240 shoots at 60 days and 90–100 at 150, while the figures for P. O. J. 100 were 100–170 and 82–86 respectively. Another observer of J. 247 found that, while the rows had 300 to 400 shoots (in one case 415) when three months old, at eight months they had only 110. It is obvious that there is far more light during the earlier periods of the cane's growth, and a far greater number of shoots are then encouraged to grow out from the sleeping buds than can be permanently maintained. The air move freely through the leaves, the soil is adequate ana manures and water can be added to meet all requirements : it is light alone which we cannot increase. This heavy mortality has only been fully studied in the thick tropical canes : our observations made for several years at Coimbatore would seem to indicate that there are nothing like so many deaths among the Indian canes during their growth.

Anything tending to the growth of a healthy cane plant has its effect on tillering, a fact which every careful observer has no doubt noted. The amount of air, food, and water available, therefore, has its influence. In a cane field it may often be noticed that particularly large bunches of canes are met with here and there, and many lessons may be learnt from a study of these. Where irrigation is employed, the bunches are usually bigger along the sides of the water channel : and this suggests that the duty of water has not been sufficiently studied. Low-lying places in heavy soil generally

produce stunted, unhealthy plants with few branches : aeration of the soil is a limiting factor in the growth of the sugarcane and therefore in its tillering capacity : where irrigation is practised it is especially necessary also to see to the adequate drainage unless this is naturally provided in free self-draining soils. In places where manure heaps have stood, great bunches of cane may be observed and such spots may often be marked from a distance, because the canes are higher and of a darker green. In all of these cases it is seen that a proper treatment of the soil will assist the cane in its tillering power, and the point is here emphasized because one worker in Java (Struben) has thought fit to construct an elaborate argument to the contrary. Killian, in Java, has published an interesting paper on the results of his experiments on the influence of various manures on tillering, and has shown that it is greatly increased if suitable manures are employed ; of all that he tried the palm is given to well-rotted pen manure. Here we have moisture conserved, the ground aerated, nitrogen-forming bacteria encouraged, and other necessary salts added.

The amount of light present and the quantity of suitable food available are thus of immediate effect on tillering, and the best way in which to regulate all of these is by a proper system of spacing. The accurate placing of the plants in the field is often the key to the whole situation. Spacing experiments have been made wherever the sugarcane has been grown, but too often the results with one variety and soil have been taken as a standard without proper consideration of the fact that there should be a series of gradations dependent on the individual field and the kind of cane planted. In this matter there is inexhaustible scope for experiment on every plantation, and the maximum output cannot be considered to have been obtained until the matter has been thoroughly threshed out. Let us consider some of the results obtained in these experiments, as a sample of the work to be done. In the Godavari delta, in Madras, where only thick tropical canes can be profitably grown and where immense yields can be obtained, it was the custom to plant the sets at the rate of 25,000 or more to the acre. Tops are not usually available, as these are the perquisite of the owners of the

cattle hired for milling, and the cutting up of whole canes is an important item in the farm budget: the cultivator was willing to put by from 30 to 40 rupees per acre for seed cane. One of the first experiments in the Samalkota farm in this area was therefore one on spacing, sets being planted from 4,000 to 30,000 to the acre; the result showed that from 12,000 to 15,000 were ample for the highest yield, with variations according to the kind of cane planted. This single experiment has resulted in the saving of something like 20 rupees per acre. Stubbs, in Louisiana, laid down a series of experiments in 1892–94 in which he planted the sets in 5 ft. rows and 6 in., 12 in. and 18 in. apart in the row. The following table gives his results.

Spacing in the row	Number of sets planted (March)	Shoots in June	Shoots at harvest (October)	Average weight of each cane	Tonnage
	lb.			lb.	
6 in	17,600	72,325	39,050	2·17	42·55
12 in.	8,800	51,188	32,964	2·49	41·60
18 in.	5,860	37,230	29,070	2·60	37·24

The wider spacing produced more shoots per plant and to a greater extent more canes per clump at harvest; there were however fewer canes reaped per acre and, although these were heavier, the tonnage was also less. Where planting material is abundant, close planting would thus appear to be more profitable. But the difference between 6 in. and 12 in. plots is so small that one wonders whether a 9 in. spacing would not quite equal a 6 in. The numbers of deaths shown in the table is arresting, especially in the closer planted rows, but it is difficult to see what can be done to prevent this. In Java where the cost of seed cane is relatively high because of the necessity for nurseries at a considerable distance from the estates, the whole question assumes a different aspect, and the spacing experiments have been conducted in much greater detail, much information having been accumulated as to the tillering power of the different varieties on different fields, but a study of this work would take up too much space in this article. Some details may be found of the Java work in the Memoir quoted above.

NATIONAL PHYSICAL LABORATORY TRACTION DYNAMOMETER FOR AGRICULTURAL TRACTORS.*

BY

J. H. HYDE, A.M. Inst. C.E., M.I.A.E., A.M.I.M.E.

In the summer of 1919 the Laboratory was approached by the Society of Motor Manufacturers and Trades with a request for assistance in the recording of draw-bar pulls of agricultural tractors at Lincoln in September of that year on the ground that no suitable British-made draw-bar provided with recording apparatus was available for the purpose. It was required that the draw-bar in these trials should be attached to the forward turntable of an ordinary road trailer which would be loaded and braked on the rear wheels in order to provide sufficient road resistance to enable the maximum draw-bar effect of the tractors to be determined. In the arrangement adopted the pull of the tractor was transmitted through a bell-crank lever to a leather diaphragm fitted to a box containing water. The diaphragm box was connected by a flexible pipe to a recording pressure gauge actuating a pen. The motion of the recorder paper was produced by means of gearing from the front wheels of the tractor.

In the present year the Laboratory received a similar request from the Royal Agricultural Society of England in conjunction with the Society of Motor Manufacturers and Trades in connection with the measurement of draw-bar pulls and speeds of tractors under ploughing conditions at the trials to be held at Lincoln in September-October 1920. The Executive Committee of the Laboratory agreed that all possible help for the successful carrying out of the trials should be

*Reprinted from *Engineering*, dated 26th November, 1920.

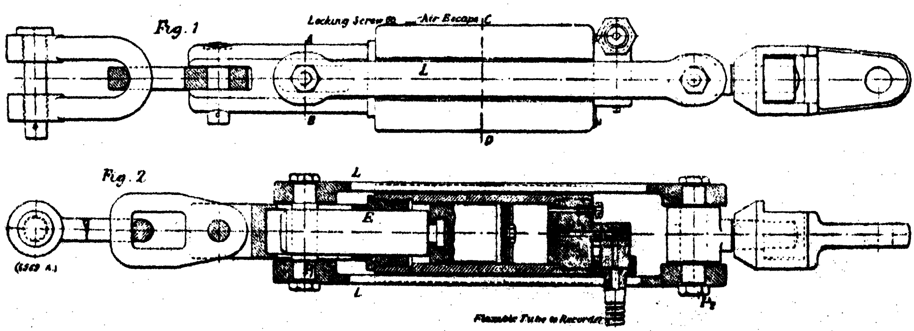
given by the engineering department and a special dynamometer was designed and constructed at the Laboratory for the purpose.

The design of the instrument was influenced by the necessity of producing a dynamometer which would be capable of measuring and recording the draw-bar pull and speed of a tractor engaged in ploughing special consideration being at the same time given to the fact that it was undesirable to separate the tractor and plough by apparatus which would in any way interfere with the proper working of the plough or with its control by the tractor driver.

For the purpose of competitive tractor trials, the dynamometer would be required for use with many different makes of tractors and ploughs, and it could not be guaranteed that a suitable position for apparatus could be provided on either; further it was desirable that the dynamometer should be capable of being quickly attached to or detached from one tractor and transferred to another. In consideration of these requirements it was decided to separate the dynamometer proper from the recording instrument and to place the latter on a light-wheel carriage which would be either wheeled or towed alongside the tractor under test.

THE DYNAMOMETER.

An elevation and section of the coupling between the tractor and plough are given in Figs. 1 and 2. It consists of a cylinder and



plunger, the former being attached to the draw-bar of the tractor and the latter through links, to the plough. The pull on the coupling

sets up a pressure in the oil confined in the cylinder, and this pressure is transmitted to a recording pressure gauge by a flexible hydraulic tube. The best flexible tube which could be obtained would safely withstand an internal pressure of one ton per square inch without reduction of flexibility, and as the dynamometer was required for pulls up to three tons, a diameter of plunger of approximately 2 in. was, therefore, necessary.

Fig. 3. SECL ELEVN ON C.D.

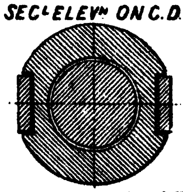
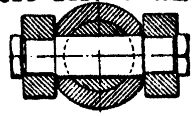


Fig. 4 SECL ELEVN ON A.B.



The cylinder was made of steel and the plunger of bronze, the clearance between the two was made 0·001 in., and the plunger was provided with a very thin packing ring of oiled leather. In order to avoid a gland the draw-bar pull was converted to a thrust on the plunger by means of the links L, L, and the pins P_1, P_2. The thrust on the plunger is transmitted through the second plunger E, which is suitably guided in a continuation of the cylinder, and the connection between the two plungers is a loose one in order to allow the larger plunger to float freely in its cylinder. The pin P_1 passes through the slots in the guide-piece.

The connection to the tractor draw-bar was made in such a manner that the cylinder could not rotate, but the opposite end of the dynamometer was provided with a swivel attachment for the plough. A rubber cover over the front portion served to exclude dust and grit from the interior of the cylinder.

The recording instrument.

The recording instrument was mounted on a two-wheeled carriage which was towed by the tractor, a suitable hitch being made to prevent damage to the connecting hydraulic tube. Fig. 5 shows the general arrangement of the carriage and Fig. 6 of the recorder. The latter consists of a standard Schaffer and Budenberg pressure recorder considerably modified for the present purpose by the addition of a second Bourdon tube, a clock, and paper driving device. The recording paper is driven through gearing and a chain drive

from one of the carriage wheels, and three speeds of the paper are provided for, namely, 1 in. of travel to 100 ft.; 50 ft. or 10 ft. motion of the carriage over the ground. The speed change can be made while running if desired. As the recorder proper rests on thick felt pads, the final drive is made by means of a leather vee belt adjustment of the tension of which is provided for. The hydraulic tube

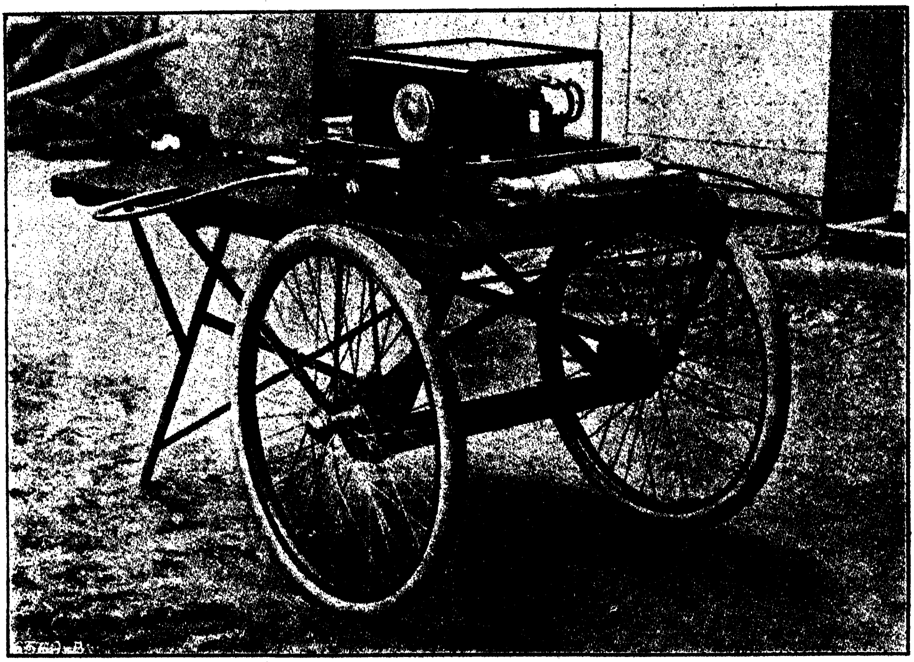


Fig. 5. General arrangement of the carriage.

from the dynamometer is connected to a small valve-box V, Fig. 5, by which the pressure can be diverted to either of two Bourdon tubes 1 and 2, shown in Fig. 6.

The motion of the end of each Bourdon tube is magnified by the pen mechanism 4, which is such that the travel of the pen is 4 in. for a maximum draw-bar pull of 4,000 lb. using tube No. 1, and 3¾ in. for a maximum pull of 7,000 lb. using tube No. 2. The pen mechanism can be transferred to either tube by transferring the screw 7, which forms the link pivot; the change can be effected during a test if required.

A clock 3, shown in Fig. 6, is provided for indicating time on the record paper. An electrical contact is made at equal pre-determined intervals of time which can be varied from 2 seconds to 6 seconds, and the pen 5, which normally draws a straight line, is momentarily moved to one side when the contact

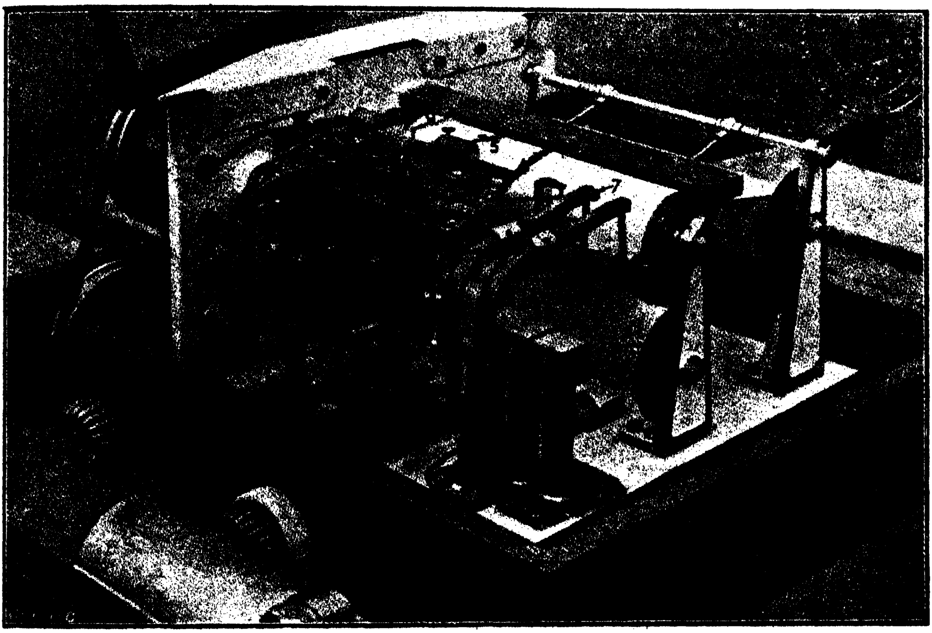


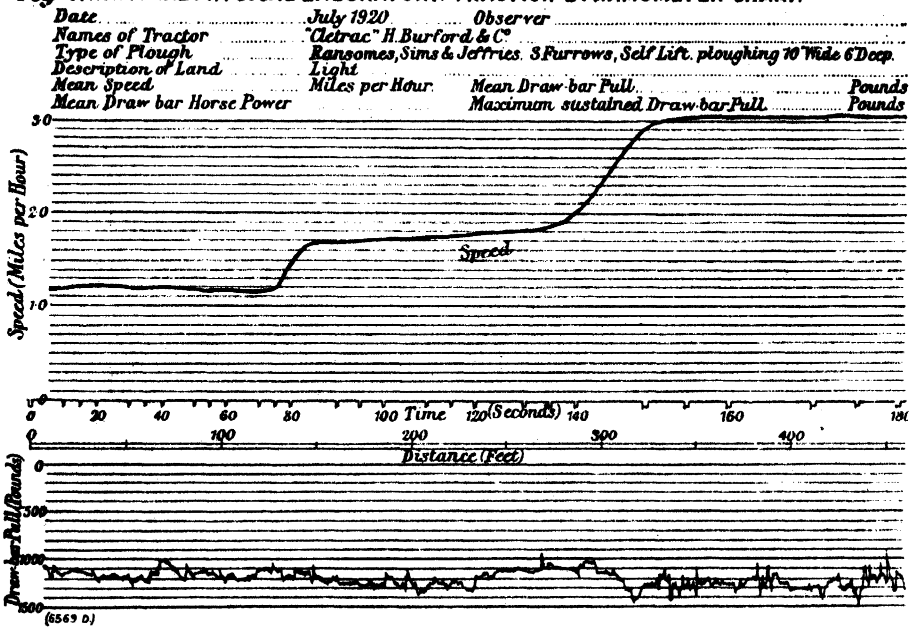
Fig. 6. General arrangement of the recorder.

takes place. A robust escapement for the clock is provided, and was found in practice to work extremely well, there being no apparent variation in the time intervals recorded, or in the total time even when the carriage was travelling over very rough ground and subject to much shock. In order that the number of time intervals indicated may be readily counted, every fourth contact is missed. This will be seen in Fig. 7. Pen 6 is provided for recording revolutions of the tractor engine, or of the tractor driving wheels, and is identical with pen 5.

An oil pump taking oil from a small reservoir placed under the carriage, serves to prime the dynamometer and recorder. This pump is shut off when the apparatus is working. It will be observed that the measured distances on the chart between indications of equal

time intervals are directly proportional to the speed, because the travel of the paper is proportional to the distance travelled. The average speed for any interval of 5 seconds can, therefore, be readily

Fig. 7. NATIONAL PHYSICAL LABORATORY TRACTION DYNAMOMETER CHART.



obtained, and the curve of speed plotted on the chart. When the speed is low and variable, this method for recording is preferable to using a centrifugal instrument.

Calibration.

The apparatus was calibrated by direct loading. The dynamometer coupling was hung from a crane hook and supported a cradle carrying a dead load which was increased by 500 lb. at a time. The indications of both pens were taken in turn and were found to agree precisely with those obtained by calculation from the oil pressure and the sectional area of the cylinder. When the load was 2,000 lb. a shift of the pen point of 0·01 in. could be clearly seen due to a gently added load of 10 lb. It was necessary to provide a small tapping device, consisting of the essential parts of an ordinary electric bell, to free the pen mechanism in order to enable it to

record so small a load, but it was not necessary to use this during a test because the motion of the recorder carriage itself provided sufficient vibration for the purpose. The calibration left no room for doubt that the friction of the packing leather of the plunger in the dynamometer cylinder was small enough to be neglected. The sensitivity did not appear to be materially affected by the use of thick oil in the cylinder, and consequently for ploughing tests on stony ground or stiff land where the pull is very variable, it is advisable to use thick oil in order to damp the vibrations of the recording pen. Fig. 7 is a specimen of the dynamometer chart, reduced in size, obtained from a tract-laying machine drawing a three-furrow plough in light loamy soil.

In this test the speed of the tractor was purposely varied in order to ascertain the variation in draw-bar pull. The chart indicates an increase in draw-bar pull from 150 lb. at 1·2 m.p.h. to 1,250 lb. at 3·05 m.p.h. The speed curve has been plotted from the time intervals and distance recorded.

FINAL REPORT OF THE GRAIN PESTS (WAR) COMMITTEE APPOINTED BY THE ROYAL SOCIETY.

In June, 1916, the Council of the Royal Society appointed a Grain Pests Committee with Prof. W. A. Herdman, C.B.E., F.R.S., as Chairman, to make investigations "in relation to the damage done to grain by insects." In addition to the scientific experts appointed by the Royal Society, the Committee included representatives of the Board of Agriculture, the milling trade and the Local Government Board. Since 1916 the Committee have prepared a number of very valuable reports which were published by the Royal Society. The final report, No. 10 of the series, which has been drawn up by the Chairman, gives a summary of all the work carried out. As it contains a mass of information of general interest to workers in India, we reproduce Prof. Herdman's summary in full.

Summary of researches and publications.

The Committee has issued two series of publications :—(1) Six "Memoranda" which were intended to be temporary and provisional, for the purpose of making known speedily from time to time to the Council of the Royal Society, the Royal Commission on Wheat Supplies, our corresponding committees in the Colonies, and other interested bodies, the progress of the investigations and any conclusions arrived at ; and (2) ten "Reports" of a more detailed and permanent nature and which for the most part superseded the "Memoranda."

Memorandum No. 1 (July, 1917) dealt with current views as to the damage done to stored grain and flour by insects and mites, and drew attention to the methods of prevention adopted in the United States and Canada, *viz.*, the application of moderately high temperatures, and in India, where the grain is passed at intervals over a current of air so regulated as to remove the adult weevils and

damaged grain. It was pointed out also that low temperatures and dry conditions are unfavourable to grain insects.

Memorandum No. 2 (December, 1917), by Miss H. M. Duvall, was the first of a series of publications by Prof. Newstead and his assistants, dealing with their investigation of the grain mites. These investigations recorded the species of Acarida concerned, the nature of the resulting injury to the grain and flour, the conditions under which the mites live and multiply, the sources of infection and practical methods of prevention. As the later Reports (Nos. 2 and 8) by Prof. Newstead cover the whole field of investigation, no further summary of this Memorandum is necessary.

Memorandum No. 3 (January, 1918) was a report, drawn up by the Chairman to the Council of the Royal Society, on the progress of the work.

Memorandum No. 4 (December, 1918), the second Memorandum on mites by Prof. Newstead and Miss Duvall, consisted largely of a reprint of the economic and experimental section of their Report No. 2, issued in this form for convenience of circulation to millers, at the request of Mr. A. E. Humphries. A large edition, illustrated by plates showing the characteristic appearance of the ravages of acarids in grain and in flour, was printed off and distributed to the trade at the request of the Incorporated National Association of British and Irish Millers.

Memorandum No. 5 (March, 1919) was an interim report to the Council of the Royal Society, drafted by Mr. Fryer at the request of the Committee, for the purpose of making suggestions as to future grain pests investigation in this country. This Memorandum was forwarded by the Council to the several Government Departments concerned.

Memorandum No. 6 (December, 1919), by Mr. H. R. Rathbone of the Royal Commission on Wheat Supplies, was prepared for the special purpose of laying before the Committee the methods and results of the Australian experiments under the following circumstances:—

In the Spring of 1917, after consultation with this Committee, the Royal Commission on Wheat Supplies sent an entomologist

(Prof. Maxwell Lefroy) and a business man (Mr. R. A. Love) to Australia to investigate and report upon the condition of the vast supply of grain accumulated there. On their return the Royal Commission suggested that it might be advisable that the Grain Pests Committee should hear and discuss the Australian results. The Committee appointed a special meeting for the purpose, and as it was found impossible to secure the presence of Prof. Lefroy, through the kind offices of Mr. Hugh Rathbone (a member of the Royal Commission) Mr. Love attended the meeting and laid before the Committee a detailed account of the observations and remedial measures, illustrated by photographs and plans of the machinery adopted for freeing the stored grain from insect pests. The Committee invited Mr. Love to put his remarks in writing for publication, but at Mr. Love's request the account which the Committee issued as their Memorandum No. 6 was written by his colleague, Mr. Hugh Rathbone. In addition to the description of the Australian results, this Memorandum contained some general remarks upon the effect of pests upon grain which, coming from a leading member of the grain trade and a member of the Royal Commission, were of interest in connection with the work of the Committee. The methods adopted in Australia as a result of the Royal Commission's investigations were, in brief, (1) to temporarily seal up the more heavily infested lots with a covering of malthoid and to pump in carbon dioxide. The wheat was then left until such time as it could be more effectively dealt with by (2) passing it through a heated sterilizing chamber at a temperature of 140°—145° F. For further details of the machinery and methods reference must be made to Memorandum No. 6.

Report No. 1 (May, 1918) recorded in detail Prof. Dendy's first series of experiments on the effect of air-tight storage upon grain insects. The object of this and succeeding reports by Prof. Dendy and his assistants was to provide definite experimental evidence with regard to the effect of hermetical sealing upon weevils, so as to test the scientific basis for the native practice in India and other parts of the world of storing grain in underground more or less air-tight pits. Opinions have differed in the past as to whether

any ventilation is necessary for the existence of grain pests, and as to whether the immunity of such stored grain from weevils is due to the absence of oxygen necessary for the respiration of the insects or to the lethal effect of the carbon dioxide produced by the respiratory processes both of the weevils and of the grain itself.

The eleven experiments, differing slightly in character, described in this report, all demonstrate the lethal effect of hermetical sealing upon the weevils *Calandra granaria* and *C. oryzæ*, but further experimental work seemed necessary in order to determine what factors were at work in producing the lethal effect. Prof. Dendy claims that within the limits of a wide range of conditions as to temperature, moisture, and degree of weevilling, hermetical sealing is a very effective method of dealing with the weevil problem; and that when once the initial difficulties of construction have been surmounted the method of air-tight storage seems likely to prove extremely valuable wherever large quantities of grain have to be stored for long periods, especially in warm climates.

Report No. 2 (October, 1918) is mainly occupied with a detailed account by Prof. Newstead and Miss Duvall of the acarids of stored grain and flour. But it also contains two Appendices, one on the bacteriology of some samples of damaged flour by Dr. J. M. Beattie, Professor of Bacteriology in the University of Liverpool, and the other by Mr. Humphries, member of the Royal Commission, recording some experiments on the introduction of mites into flour of known composition. Most of this work on mites was carried out in the University of Liverpool, supplemented by observations at the docks. Liverpool is the chief port of entry for Canadian wheat, and it is also the largest storage and milling port in the United Kingdom. Hence it is possible, in addition to work in the laboratories, to survey the wheat in ship, granary, and mill, and also (what is of special importance in an investigation of this kind) to keep in constant touch with the practice and requirements of the trade.

Four species of Tyroglyphid mites were found in the grain, by far the most important being *Aleurobius farinæ*, which is also the only mite found up to that time in flour. This mite is

responsible for most of the damage to both wheat and flour in the Liverpool granaries.

The chief conclusions arrived at in this Report are :—

1. Mites will not injure wheat and flour in which the moisture is 11 per cent. and under, whatever the temperature may be. They may flourish and increase exceedingly when the moisture is over 13 per cent.
2. Given favourable (to them) moisture conditions, increase is very rapid at temperatures between 60° and 75° F., less so between 50° and 60° F., while between 40° and 50° F. increase is slow.
3. The remedy for mite-infested wheat is to screen it thoroughly, in order to remove as many of the mites as possible, and subject it to some treatment whereby the excessive moisture is reduced, such as a blast of hot air followed by cooling.
4. The injury to flour is much more serious and much less readily combated than in wheat. Flour which is heavily-infested is unfit for human consumption.

Professor Beattie examined some samples of badly infested flour and isolated three organisms—a coccus and two bacilli—which seemed to be concerned in causing the damage. The bacterial degeneration of the flour only takes place when a certain amount of moisture is present, and the bacteria are probably introduced by the excreta of the mites.

In Report No. 3 (November, 1918) Prof. Dendy and Mr. Elkington gave the results of their further experiments on the effect of air-tight storage on grain insects. They produced further evidence as to the efficacy of hermetical sealing, and extended their observations to the immature stages of the species of *Calandra* and also to certain other grain beetles, and the notorious flour moth *Ephestia kuhniella*, and they found that all these insects are destroyed by hermetical sealing under the same conditions as the grain weevils. In the same Report Prof. Dendy recorded a series of experiments showing that the two small grain beetles *Tribolium castaneum* and *Silvanus surinamensis*, although frequently found in

damaged grain, are unable to attack sound wheat. They are apparently only " secondary " grain pests, feeding upon the debris produced by the attacks of weevils, and incapable themselves of injuring sound grain.

Prof. Dendy also notes in this Report the great attraction which water had in his experiments for certain species of weevils.

In Report No. 4 (April, 1919) Prof. Dendy has two short notes. The first, on the phenomenon known as " webbing " in stored grain, which he showed to be due to the spinning of silk by the larvæ of a very destructive insect, *Ephestia elutella*, and possibly also by other insects.

The second note is on the occurrence of live insects in tins supposed to be hermetically sealed. It was shown that tins, supposed to be " intact," which contained live insects, when tested for leakage by plunging in hot water, showed escape of air-bubbles and were not really air-tight. This note is claimed to prove that the supposed power of some insects to remain alive indefinitely in hermetically sealed tins is a fallacy. It also shows the importance of testing such tins for leakage before they are put in store.

Report No. 4 contained also the result of the work by Dr. Edkins assisted by Miss Nora Tweedy, on the effect of various gaseous reagents upon the flour moth (*Ephestia kuhniella*) and other insect pests found in flour. The gases experimented with included formaldehyde, sulphur dioxide, ammonia, ether, alcohol, extracts of " Keating " and ozone. For various reasons all were found unsatisfactory with the exception of ozone. The experiments with this gas are given in detail, and the following conclusions are drawn :—

Ozone appears to prevent development of *Ephestia* in flour in concentrations of about 50 in a million, if delivered in dry air, for the following reasons :—

1. It tends to destroy the moth, though not to kill the larvæ to any appreciable degree.
2. It appears to inhibit the transformations. Though the animals may not be destroyed they seem to be deprived of their normal powers of continuing development (absence of cocooning and egg-laying).

3. The presence of ozone in the air in a concentration of more than five in a million would be injurious to human life. It could therefore be used in closed circuits in perhaps 50 in a million, but not in the air to be breathed by man.

Report No. 5 (July, 1919) deals with the prevention of heating in wheat by means of air-tight storage, by Prof. Dendy and Mr. H. D. Elkington. The argument used is, that as the "heating" is due to processes of fermentation which depend upon the presence of oxygen, total deprivation of oxygen such as occurs in air-tight storage must result in the prevention of heating. The experiments described in the report demonstrate that "heating" of wheat does not take place in hermetically sealed vessels under the conditions given, and it is fairly safe to argue that it could not take place in large masses of grain in air-tight storage.

Report No. 6 (January, 1920) contains the third and final part of the work by Prof. Dendy and Mr. Elkington on the effect of air-tight storage on grain pests. It consists of a very complete and detailed physiological and chemical investigation of the causes and accompanying conditions of the lethal effect observed. The chief conclusions arrived at are as follows :—

1. Grain insects sealed up in air-tight vessels, with or without wheat, succumb as soon as the oxygen has been used up, a corresponding amount of carbon dioxide being produced.
2. The only gases present in such sealed vessels, under normal conditions, are oxygen, nitrogen, and carbon dioxide.
3. The amount of carbon dioxide given off by live wheat in air-tight vessels varies directly with the moisture content and the temperature.
4. The complete absence of oxygen is alone sufficient to kill weevils without taking into account the presence of carbon dioxide though they are able to remain alive for a considerable time when only small percentages of oxygen are present.

5. Carbon dioxide exerts a poisonous effect upon weevils apart altogether from the question of diminished oxygen pressure. Thus at 30°-31°C. *Calandra oryzæ* was killed in less than twelve days in an atmosphere containing from 14·08 to 22·56 per cent. of CO_2, though 13·88 per cent. of O_2 still remained.
6. Pure (moist) carbon dioxide is less fatal in its effects than carbon dioxide with a small admixture of oxygen.
7. Pure (moist) carbon dioxide acts almost instantaneously as a narcotic, under the influence of which weevils may remain motionless for a long time without losing their power of recovery.

The Report terminates with a general discussion on the efficacy and advantage of air-tight storage for cereals, in which it is pointed out that it is highly desirable, as a sequel to the laboratory experiments, that the practicability of the method should be tested on a commercial scale.

The advantages of air-tight storage are summed up as follows :—

1. It sterilizes the grain by destroying insects in all stages, or other vermin which may be present.
2. It prevents, absolutely, the access of insect and other vermin.
3. It prevents even grain with a high moisture content from becoming mildewed, as we have shown by experiments not described in these reports.
4. It prevents even grain with a high moisture content from heating (but it does not prevent the development of acidity, due presumably to anaerobic fermentation, if the moisture content is excessive).
5. It prevents the absorption of moisture from the atmosphere, so that grain, if stored dry, will remain dry.
6. It saves labour and expense by doing away with the necessity for turning the grain over, or running it from one silo into another, in order to prevent heating.

For further details both as to the conditions and results of the experiments, and also as to the practical applications to the storage

of grain in large quantities reference must be made to the Report (No. 6) itself.

Report No. 7 (January, 1920) contains the last part of the laboratory experimental and bionomic work by Prof. Dendy and Mr. Elkington, and deals with the vitality and rate of multiplication of the grain weevils *Calandra* and *Rhizopertha* under various conditions of temperature and moisture. In *C. oryzæ* they find an increase of as much as 700-fold in 16 weeks, at an average temperature of 82·5°F., which may be regarded as the optimum temperature for the breeding of both species of grain weevils. In both species also the lower limit for breeding is about 65°F., and multiplication in this country takes place only during the warmer months.

The summary of results from these experiments and observations includes the following :—

1. Under suitable conditions of temperature and moisture, and with an abundant supply of wheat, *Calandra oryzæ* and *C. granaria* show a very high rate of increase and breed all the year round.
2. The optimum temperature for the breeding of *Calandra oryzæ* and *C. granaria* is about 82°F., for *Rhizopertha dominica* somewhat higher.
3. At all temperatures, and under all conditions when breeding takes place at all, *Calandra oryzæ* increases much more rapidly than *C. granaria*, the maximum observed for the former species being a 700-fold increase in 16 weeks, at an average temperature of 82·5°F. For this reason *C. oryzæ* is a more serious danger than *C. granaria*, unless, indeed, in this country the higher rate of increase is counterbalanced by the higher death-rate of the adults in winter.
4. At ordinary room temperatures in this country both *Calandra oryzæ* and *C. granaria* multiply only during the warmer months of the year, the lower temperature limit for multiplication being probably about 65°F., while for *Rhizopertha* it is probably about 70°F.

5. At ordinary room temperatures nearly all adults of *Calandra oryzæ* are killed off during the winter, but large numbers of larvæ survive in the interior of the grains. The adults of *C. granaria*, on the other hand, survive the winter in large numbers, the death-rate being little, if any, higher than at other times of the year.
6. The adults of the three species show remarkable differences in their susceptibility to cold. After being kept at a temperature of 33°—36°F. for 11 days, 91 out of 100 *C. granaria* recovered, only three out of 100 *C. oryzæ* showed very feeble signs of life, and none out of 100 *Rhizopertha dominica* recovered.
7. *Rhizopertha dominica* is less susceptible to high temperatures than the two weevils, the lethal temperature for an exposure of three minutes being about 146°F. for the former and between 120° and 131°F. for the latter (in the adult condition).
8. An exposure to a temperature of 145·5°F. for five minutes is sufficient to kill the larvæ of *C. oryzæ* and probably to sterilize the wheat completely as regards all insect life.
9. Although a moist atmosphere is undoubtedly more favourable than a dry one for the two weevils, both species can live and multiply in a dry incubator, *C. oryzæ* increasing much more rapidly than *C. granaria*, provided the initial moisture content of the grain is sufficiently high.
10. Very dry wheat is less liable to attack by weevils than wheat with a moderate or high moisture content, but wheat readily absorbs moisture in a damp atmosphere, and thereby becomes much more susceptible to weevilling.
11. *Rhizopertha* can withstand dry conditions better than either of the two weevils.

12. *Calandra oryzæ* and *C. granaria* are both likely to be serious pests in this country, but little is to be feared from *Rhizopertha dominica* under ordinary temperature conditions.
13. In addition to the damage done by actual consumption of the grain, the presence of weevils results in extensive fouling with fæcal matter encouraging the absorption of moisture and the ultimate rotting of the whole mass. In large quantities of wheat the process of decay is doubtless accelerated by rise of temperature due partly to the presence of insects and partly to "heating of the wheat."

Report No. 8 (October, 1920) gives the continuation of Prof. Newstead's work, assisted by Mr. H. M. Morris, in which he discusses the mites found in stored grain and flour at Liverpool under the heads (1) Morphology and Bionomics and (2) Economic and Experimental. He finds that in addition to *Aleurobius farinæ* discussed in his first report, two other mites, *Tyroglyphus longior* and *Histiogaster entomophagus*, are of primary importance, as they are capable of causing considerable damage to stored flour.

The other chief conclusions arrived at are as follows :—

1. A relatively high moisture content in both wheat and flour is essential for the existence of the various species of acari.
2. Preventive measures are far more satisfactory than remedial measures.
3. Attacks by mites may be prevented by storing only flour, the moisture content of which is below 11 per cent. in the temperate zone, and a much lower percentage in tropical countries.
4. The storing of uninfested flour in hermetically sealed receptacles would no doubt be efficacious if properly carried out; but our experiments show that if the flour is already infested with mites some may survive even after hermetic sealing for over two months.

Prof. Newstead also gives a report on the non-parasitic or forage acari of the family Tyroglyphidæ. These have sometimes been found on the British Army horses in France and sent to us for identification. They are no doubt accidental migrants from the fodder or oats and in no sense parasites, but their resemblance to the closely allied Sarcoptids, which cause acariasis or mange, has in some cases led to the needless isolation of numbers of horses. The Liverpool veterinary surgeon, Captain Noel Pillers, who had much experience of such mites on horses in France during the war, has contributed some clinical notes to Prof. Newstead's report.

In Report No. 9, Mr. Durrant gives a complete list of all the grain pests identified during the work of the Committee, with information as to their relative abundance and importance as pests, along with their geographical distribution, and a description of those hymenopterous parasites of the grain pests which proved to be new to science or unrecognized.

In this Report (No. 9) also, Prof. Goodrich has an article giving the result of his researches on the hymenopterous parasites of grain pests. The report shows that the commonest species are *Chætopsila elegans* and *Lariophagus calandræ* belonging to the family Chalcididæ, that they attack and kill the larvæ of *Rhizopertha dominica*, *Calandra oryzæ*, and *C. granaria*; and that since the chalcids often occur in large numbers, and the beetles named above are the most destructive insects found in grain, the parasites are valuable allies in the fight against grain pests. But although they act as a check on the multiplication of the beetles they do not exterminate them. Both weevils and hymenopterous parasites survive for an indefinitely long time in infested wheat. The report shows that this is due to a balance being established, owing to the parasites themselves falling a prey to a carnivorous acarid.

A STUDY OF THE INDIAN FOOD PROBLEM.*

BY

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(Concluded from Vol. XVI, Pt. III, p. 324.)

THE AVERAGE SUPPLY.

IN the previous portion of this paper the total requirements of grains in British India for food, cattle and seed were ascertained; and the total available supply after correcting the figures of gross outturn by allowances for wastage, and for imports and exports, was calculated. To bring the figures of total supply in conformity with actual fact, however, or in other words to find the quantity actually available for consumption and other purposes, it is necessary to make an allowance for the amount carried over to the next year when the harvest turns out good in a particular year. I think if we assume that two-thirds of the excess over the average supply is carried over to the next year it will serve our purpose. To determine the average supply the total supplies of all seven years are added together and the sum divided by seven. The result gives the average supply of the middle year (1914–15). It amounts to 55·22 million tons. If the quantity is annually increased by 0·5 per cent. (the rate of the natural growth of population in British India during the period 1901–1911) for the last three years, and decreased by the same rate for the first three years, the results give

* Reprinted from *Ind. Jour. Eco.*, Vol. III, Pt. 2.

the average supply for each year. The average supply thus calculated stands as follows :—

	Millions of tons
1911–12	54·41
1912–13	54·68
1913–14	54·95
1914–15	55·22
1915–16	55·50
1916–17	55·78
1917–18	56·06

On comparing the above figures with those of the total supply, it will be seen that the total supply falls short of the average supply in the following years to the following extent :—

	Millions of tons	Percentage
1912–13	2·52	4·6
1913–14	6·49	11·8
1914–15	1·18	2·1

And the total supply exceeds the average supply in the following years as follows :—

	Millions of tons
1911–12	1·18
1915–16	2·46
1916–17	4·74
1917–18	1·74

QUANTITY OF FOOD-GRAINS ACTUALLY AVAILABLE FOR USE.

If we carry over the two-thirds of the excess of food-grains over the average supply of each of the above four years to their respective next years, we get the quantity actually available for consumption and other purposes. In the case of the remaining years, the total supply of each of these years represents the quantity available for use. The quantity thus calculated stands as follows :—

	Millions of tons
1911–12	54·80
1912–13	52·95
1913–14	48·46
1914–15	54·04
1915–16	56·32
1916–17	57·90
1917–18	58·06

THE DEFICIT.

The figures for the total requirements of food-grains and the final total supply available for consumption and other purposes are placed side by side, and the reader will be surprised to find that there is a big deficit every year as given in column 4 below :—

In millions of tons

Year	Total requirements	Final total supply available for use	Deficit
1	2	3	4
1911–12	64·33	54·80	9·53
1912–13	63·60	52·95	10·65
1913–14	63·03	48·46	14·57
1914–15	65·16	54·04	11·12
1915–16	65·83	56·32	9·51
1916–17	66·19	57·90	8·29
1917–18	66·40	58·06	8·34

QUANTITY OF FOOD-GRAINS CONSUMED BY WELL-FED CLASSES.

It will greatly help us in correctly understanding the consequences of this deficit if we determine the quantity of food-grains consumed by those classes of the people who are always well-fed, *i.e.*, by those who, for one reason or another, are always in a position to get the quantity sufficient to maintain them in health and strength. In the absence of any definite information regarding the number of such people, only a rough estimate of their number can, at present, be made. Broadly speaking, the population of British India falls under two main classes :—

(*a*) Agricultural.

(*b*) Non-agricultural.

In the agricultural classes, I think, all the malguzars and proprietors of land who primarily live on the income from the rent of agricultural land, and the rich cultivators of the canal-irrigated areas of the Punjab and the United Provinces are well above the starvation level, and they may be taken to be always well fed. Amongst the non-agricultural classes, I think, those whose family annual income is above Rs. 500 will ordinarily fall in the well-fed

class. Now let us estimate the number of such people. From the Census Report of 1911 it will be seen that the number of those people and their dependents who were living on income from rents of agricultural land was 5,467,000. The canal colonies reports, and the annual reports on irrigation in India, unfortunately do not give the number of people living in all the canal colonies of the Punjab, and so, in the absence of any definite information, it will be better to assume that 75 per cent. of the ordinary cultivators and their dependents living in the canal-irrigated areas are above the starvation level. From a map showing the canal-irrigated areas of the Punjab it is easy to know the portions of the districts which are thus irrigated, and from the Census Report of the Punjab the number of ordinary cultivators and their dependents living in these parts can be approximately found. The number of ordinary cultivators and their dependents in these areas of the Punjab in 1911 was 3,151,000, and so the number of those cultivators who may be taken as always well fed comes to 2·36 millions. The number of such people in the canal-irrigated areas of the United Provinces may be taken to be 0·5 million.

Now we turn to find the number of well-fed people in the non-agricultural classes. The income-tax statistics as given in the "Statistics of British India" (Vol. II) clearly show the number of those people whose family annual income is above Rs. 1,000. In 1911 the number of such assessees was only 289,826. But we have also to find the number of those people of non-agricultural classes whose annual family income is between Rs. 500 and Rs. 1,000. Before 1903–04 the income-tax was also levied on all those persons of non-agricultural classes whose family income was more than Rs. 500 per annum, and so we know the number of assessees whose income was between Rs. 500 and Rs. 1,000 in 1902–03.[1] It was 324,044. If we assume that the increase in the number of families with an income between Rs. 500 and Rs. 1,000 during the period 1902–03 to 1911–12 was exactly in the same proportion as in the

[1] *Statistics of British India* for 1911–12 and preceding years (sixth issue), Part IV (*b*), Finance and Revenue, p. 161.

case of those in the next higher class, *i.e.*, of those with an income between Rs. 1,000 and Rs. 1,250, during the same period, a calculation gives the number of families with an annual income between Rs. 500 and Rs. 1,000 in 1911–12 as 550,200. Undoubtedly the rate of increase in the case of families with an income between Rs. 500 and Rs. 1,000 would have been somewhat greater, and it is just possible that many families may have escaped assessment in 1902–03, but for our rough estimation the above number will serve our purpose well. So the number of non-agricultural families with an annual income above Rs. 500 in 1911 was 840,026. As the average population per house according to the census of 1911 was 4·9, the total number of non-agricultural people whose family income was more than Rs. 500 was (840,026 × 4·9) 4·12 millions.

We find, therefore, that the total number of those people who may be taken to have been always well fed in 1911–12 was as follows :—

	Millions
Agricultural :	
(*i*) Those who live on rent from agricultural land ..	5·47
(*ii*) Rich cultivators and their dependents in the canal-irrigated areas of the Punjab	2·36
(*iii*) Rich cultivators and their dependents in the canal-irrigated areas of U. P.	0·50
Non-agricultural :	
(*iv*) Number of people whose family annual income was above Rs. 500	4·12
TOTAL ..	12·45

As the total population in British India in 1911–12 was 244·3 millions, it will be seen that only a little more than 5 per cent. of the people can be included in the well-fed classes in 1911, and therefore for the period under inquiry I assume that 5 per cent. of the people were always well fed, and so the quantity of food-grains consumed by them works out as follows :—

	Millions of tons
1911–12	2·42
1912–13	2·43
1913–14	2·45
1914–15	2·46
1915–16	2·47
1916–17	2·48
1917–18	2·50

But in the above calculation we have not taken into consideration one important fact that the children of every class are generally well fed. People will themselves starve, but will not allow their children to starve as far as they can ; and, therefore, if we assume that 80 per cent. of the children between the ages of 1 to 15 of the classes not included above are generally well fed, the quantity of food-grains consumed by them will stand as follows :—

	Millions of tons
1911–12	8·02
1912–13	8·06
1913–14	8·10
1914–15	8·14
1915–16	8·18
1916–17	8·22
1917–18	8·26

Adding the above quantity consumed by 80 per cent. of the children to the quantity consumed by the well-fed rich classes, we find the total quantity of food-grains consumed by all well-fed people, and it is as follows :—

	Millions of tons
1911–12	10·44
1912–13	10·49
1913–14	10·55
1914–15	10·60
1915–16	10·65
1916–17	10·70
1917–18	10·76

Percentage of the total requirement of food-grains left for the remaining population.

We have seen that 12·45 million people are ordinarily well fed in British India ; and of the total number of 82·4 million children (between 1 and 15) of the remaining population, 80 per cent., *i.e.*, 65·89 millions are also well fed ; and as the number of children of ages between 0 and 1 is 8 millions, so the total number of people who might be taken to be always well fed in British India in 1911-12 was 86·34 millions, and therefore the remaining population of British India, *i.e.*, 156·96 millions, or 64·6 per cent. of the whole population, is likely to be directly affected by the deficit. Now let us see what percentage of their requirement of food-grains

was available to them during different years of the period. If we subtract the total quantity of food-grains consumed by the well-fed classes from the total requirements for human consumption, we get the quantity of food-grains required by the remaining people, assuming them to get sufficient to maintain them in health and strength. If we further subtract the previously ascertained deficit from these requirements, we get the quantity actually available for their consumption. From the figures of the quantity actually available for their consumption, the percentage of the quantity available to the quantity required can easily be calculated. It is worked out in the table printed below.

In millions of tons

Year	Number of people directly affected by the deficit	Requirement of the people in column 2	The deficit	Quantity of food-grains actually available	Percentage of the quantity available to the minimum quantity required
1	2	3	4	5	6
1911-12	156·96	38·02	9·53	28·42	75
1912-13	157·74	38·21	10·65	27·56	72
1913-14	158·33	38·39	14·57	23·82	62
1914-15	159·32	38·58	11·12	27·46	71
1915-16	160·11	38·78	9·57	29·27	75
1916-17	160·91	38·98	8·29	30·69	79
1917-18	161·71	39·17	8·34	30·83	79
		AVERAGE	10·3		73

REMARKS ON VARIOUS POSSIBLE BASES OF CALCULATION.

Before I conclude, a few words may be said about the various methods of calculation that have been employed in the above study. I am very much obliged to Lieut.-Colonel G. I. Davys, of the Military Food Laboratory, Kasauli, and Mrs. Davys for giving me various suggestions in this connection. I am fully conscious of the fact that in the calculation of the requirement of food-grains for human

consumption I have assumed that all food-grains are of equal food value which, in fact, is not correct.

The average requirements of food-grains to keep a man in health and strength can also be calculated in the following other two ways : (1) by finding out the daily requirements of protein, fats, carbohydrates, and salts ; (2) by estimating the calories required by the average man per day, and then finding out the caloric value of the food-grains that are available for human consumption.

Both these methods are open to one objection or the other. It is just possible that a certain food-grain, say a millet, may have great caloric value but may have little nourishing or sustaining power, while a substance rich in protein, fats or other salts, may have comparatively less caloric value ; and so these methods if employed separately will give results which are not likely to agree. Lieut.-Colonel Davys has suggested to me to use the caloric method as a control for the comparison of results. I could not, unfortunately, get the figures of the caloric value of more than three or four Indian food-grains ; and so I could not accurately calculate the requirements of food-grains for human consumption by this scientific method. At first sight it appeared that the jail diet was in excess of requirements, but from my existing information on the subject I find that there appears to be a close agreement in the final results obtained by the two methods ; and I hope to establish the point much more clearly when I get full information.

It has been suggested to me that the poor people get a greater quantity of vegetables than is given to prisoners in jails ; and that rich people take a greater quantity of sugar, oil, and *ghi* as substitutes, and so some reduction ought to have been made in their requirements of food-grains. Now we know that the jails of the Central Provinces allow 3 *chhataks* of vegetables per head per day, and in the United Provinces jails only 1 *chhatak* is allowed. In my opinion, an allowance of 3 *chhataks* per day, even in the case of poor people, will represent quite a fair standard ; and if poor people take more than 3 *chhataks* a day, I consider it to be the direct result of the deficit of food-grains, because I think these poor people are

compelled to depend upon a greater quantity of vegetables, through not being in a position to get the necessary amount of food-grains.

In the case of rich people I have taken the question of substitutes into consideration in the determination of the probable degree of error. It may, however, be noted that the question of substitutes cannot influence our final results to any appreciable degree, firstly because the number of rich people is estimated to be only about 5 per cent. of the whole population, and secondly because the substitutes would not reduce their requirements of food-grains to any great extent. This will be apparent from a comparison of the standard adopted for the inquiry with the daily ration for Indian troops (combatants) and Indian followers of the Indian Army, the information about which I obtained through Prof. Jevons, after the first portion of this article was already in the press. The diet scale of Indian soldiers may well be considered as an ideal ration for full efficiency and may be assumed to represent the requirements of well-fed classes, while the Indian followers may be assumed to live on a little more than a subsistence diet. The rations for Indian troops (combatant) and followers are as follows :—

	For Indian troops[1]	For Indian followers[2]
	oz.	oz.
Atta or Rice	24	24
Dal	3	4
Ghi	2	1
Gur	2	..
Potatoes	2	..
Salt	$\frac{1}{2}$	$\frac{2}{3}$
Firewood	48	..

And the substitutes allowed are as follows [3] :—

Article short issued	oz.	Substitute	oz
Ghi	1	Dressed meat (mutton or goat)	4
		or Cooking oil ..	2
Gur	1	Sugar	1

[1] *Army Tables, Miscellaneous Services*, Part I, Table 15, as reconstructed by July Appendix to I. A. O., 1918.

[2] *Army Tables, Miscellaneous Services*, Part I, Table 16, Note 2.

[3] *Army Instruction (India)* No. 407, dated the 30th April, 1918.

From the above we see that in the Indian Army an Indian soldier is given 27 ounces of food-grains, and an Indian follower is given 28 ounces of food-grains, and this compares very closely with the standard of 28 ounces adopted for the inquiry.

Lieut.-Colonel Davys thinks that the reduction of the food-grain allowance by 6¼ per cent. for meat, eggs and fish is too high, and he suggests a reduction of 5 per cent. only. I have taken this point into consideration in the investigation of the probable degree of error. He further thinks that the wastage is put very high. As has been already noted, there are various items which can be included under the term wastage ; and it is practically impossible to calculate the exact amount of wastage in the case of each one of them. In a Resolution dealing with the measures to be adopted for the extirpation of bubonic plague, issued by the Government of India, and published in the "Gazette of India," dated the 21st August, 1920, it is estimated that in British India alone the number of black rats is 375 millions and that the quantity of grain devoured by them in the course of a year amounts to about one million tons. It will be seen that this estimated wastage by black rats alone amounts to nearly 1·5 per cent. of the annual average production of all the food-grains in India.

I have seriously thought over the whole question of wastage once again, and I feel that there is no overestimation in my assumption of 10 per cent. as the wastage from all causes. Notwithstanding this, in the investigation in the next section of the probable tendencies to error, I have, however, made allowance for a probable slight overestimation of the wastage.

CONSIDERATION OF THE PROBABLE TENDENCY OF THE ERRORS IN OUR CALCULATIONS.

Now we turn to the problem of considering briefly the extent of the probable amount of error in our calculations. It may, however, be noted that the errors are of such a nature that they cannot even be estimated with any approach to accuracy, so we can only show in what way they tend to influence

our final result. They may be treated under the following two heads :—

(*i*) those which affect the estimate of the yearly deficit of food-grains ;

(*ii*) those which affect the percentage of the quantity available to the calculated quantity required by the residuum (64·6 per cent.) of the population.

These are shown separately in Appendices I and II. From Appendix I, it will be seen that in the calculation of the deficit there are ten sources of error, and the majority of them tend to make the calculated deficit more than the actual one. All these errors, however, should not be given equal importance ; and I feel that the resulting error cannot be more than two or three per cent. ; and so it will be quite apparent that the big deficit shown every year is not at all fictitious, and it is fairly correct even from the statistical point of view.

This very slight overestimation of the deficit tends to make the calculated percentage of the quantity available to the quantity required a little less than the actual one ; but from Appendix II it will be seen that there is one more source of error which tends to make that percentage less, while two other sources of error are tending to make that percentage more than the actual one. I think, therefore, the effects of the slight overestimation of the deficit are greatly modified. Therefore, I think that the percentage of the quantity available to the quantity required by the residuum (64·6 per cent.) of the population as calculated above may be taken to be fairly correct.

CONCLUSION.

From the above study we are forced to the conclusion that even in the best year from an agricultural point of view (*i.e.*, 1916–17), and even with restricted exports of food-grains to foreign countries due to the war, so many as 160 millions of people in that year were in a position to get only 79 per cent. of the coarsest kind of food-grains to maintain them in health and strength ; and in a famine year (1913–14) the percentage fell to such a low figure as 62. Taking an average of all the seven years, it will be seen that 64·6 per cent. of

the population lives always on insufficient food, getting only about 73 per cent. of the minimum requirement for maintaining efficiency. In other words, it clearly shows that two-thirds of the population always get only three-fourths of the amount of food-grains they should have.

It is just possible that one-third of the above number (two-thirds of the population) may be getting a little less than 90 per cent. of their requirements ; and the rest of the two-thirds, or 100 million, in spite of hard labour, may be getting for a greater part of the year less than 60 per cent. of food-grains that are given to the worst sort of criminals in the jails of the United Provinces and Central Provinces. This clearly shows the gravity of the situation in which we find ourselves. The country cannot make progress in any way while such a state of affairs continues.

The above conclusions are in full accord with the experience of those who have carefully observed the conditions of living of the Indian masses in their own villages ; and they unmistakably show, as nothing else can, the urgent necessity of taking in hand immediately and in right earnest the problem of agricultural improvements along right lines, to help the Indian cultivator to raise two blades of corn where one grows now.

APPENDIX I.

FINDING OUT THE ERROR IN THE CALCULATION OF THE DEFICIT.

An error is called *positive* if it tends to make the calculated deficit less than the actual one.

An error is called *negative* if it tends to make the calculated deficit more than the actual one.

Error due to :	Whether positive or negative
1. Quantity of food-grains required by sick persons being less than that given in the standard adopted for the inquiry	−
2. Quantity required of inferior kinds of food-grains consumed by poor people being more than that given in the standard adopted for the inquiry	+

APPENDIX I—*concld.*

Error due to :	Whether positive or negative
3. Assuming that one-half of the population takes as much meat or fish as to reduce their requirement of food-grains by one-eighth during one year. (Lieut.-Colonel Davys suggests the reduction of 5 per cent. for the whole population)	+
4. Area reported for crops being less than the area for which population is reported	—
5. Taking the yield for the area for which yield figures are not available in the same proportion as those for which they are available	+
6. Taking 500 lb. as average yield per acre for other 'food-grains and pulses'	—
7. Probable very slight overestimation of the wastage ..	—
8. Area reported under the crop being less than the actual one	—
9. Yield in bad years being very likely to be overestimated ..	+
10. Yield in good years being very likely to be underestimated	—

APPENDIX II.

FINDING OUT THE ERROR IN THE FINAL CALCULATION PERCENTAGE OF THE QUANTITY OF FOOD-GRAINS AVAILABLE TO THE QUANTITY REQUIRED BY THE RESIDUUM (64·6 PER CENT.) OF THE POPULATION.

An error is called *positive* if it tends to make the calculated percentage less than the actual one.

An error is called *negative* if it tends to make the calculated percentage more than the actual one.

Error due to :	Whether positive or negative
1. Probable slight overestimation of the deficit (result of Appendix I)	+
2. Underestimation of the number of rich families earning between Rs. 500—1,000 per annum (assuming all rich families consume full allowance)	—
3. Omitting the number of rich 'ordinary cultivations' of India from other parts of the country except the Punjab and the United Provinces[1]	—
4. Not making proper allowance for vegetables, oil and *ghi* taken as substitutes by rich people, and the consequent reduction of their requirement of food-grains ..	+

[1] The number of persons in the residuum will undoubtedly be less in the case of Nos. 2 & 3.

Notes

THE "FIJI DISEASE" OF SUGARCANE.

We are indebted to Dr. E. J. Butler, Director of the Imperial Bureau of Mycology, for the following advance report on the "Fiji disease" of sugarcane, by Mr. R. J. Haskell, of the Plant Diseases Survey, United States Department of Agriculture :—

The name "Fiji disease" has been applied to this serious malady because it was first reported from the island of Fiji. Further study of the disease will doubtless lead to a better and more appropriate name.

The disease has been known in Fiji since 1905 at least. Although observed by many people, it has not been thoroughly investigated, and the only published accounts that we have thus far been able to find, by men who have studied the disease first hand, are those of H. L. Lyon and F. Muir, both of the Hawaiian Sugar Planters' Experiment Station. Their articles are published in the *Hawaiian Planters' Record*, a journal that is not widely distributed. An account has also been recently given by Otto A. Reinking ("Diseases of Sugarcane in the Philippines—Fiji Disease," *Sugar News*, L, 17–19, Nov. 1920), who used the published matter of Lyon as a basis for his note.

This disease occurs in the Fiji Islands, New Guinea, New South Wales, and has just been discovered in the island of Mindoro of the Philippine Islands. The disease was found in Fiji by F. Muir in the early part of 1910, and reported on by him (*Ha. Pl. Rec.*, **3**, 197, 1910). It was also reported on from Fiji by H. L. Lyon (*Ha. Pl. Rec.*, **4**, 230–232, 1911) who made a special study

of the disease as it occurred in that locality. The disease was reported from New Guinea by Mr. D. S. North, of the Colonial Sugar Refinery Company of Australia, who wrote to Lyon that one of the Colonial Sugar Company's men had found the disease to be very prevalent in parts of New Guinea (Lyon, H. L., "Fiji Disease in New Guinea," *Ha. Pl. Rec.*, **12**, 200, 1915) on native cane. In view of this discovery Lyon expressed the opinion that the original home of the disease was very likely New Guinea, from which place it had spread to Fiji and Australia.

The occurrence of the disease in Australia is indicated by Lyon (*Ha. Pl. Rec.*, **12**, 200, 1915), and has been reported by D. S. North as appearing in experimental plots on New Guinea cane, and by A. H. Haywood (*Agr. Gaz., New So. Wales*, Nov. 1920, pp. 773–780) who states that it is now a problem with which growers will have to contend.

The presence of the Fiji disease in Mindoro, P. I., has been suspected for the last three years. W. H. Weston, of the U. S. Department of Agriculture, in 1919–20 learned of this suspicion from C. W. Hines, of the Bureau of Agriculture at Manila, and a published note on the possible occurrence of the Fiji disease in Mindoro has appeared in the report of the Pest Control Section of the Bureau of Agriculture (*Phil. Agr. Rev.*, **12**, 93, 1919). During the Christmas vacation (1920–21) Prof. Otto A. Reinking, of the College of Agriculture at Los Banos, went to Mindoro and found the Fiji disease there doing great damage. According to one of the planters it was present on the island as early as 1916. Prof. H. A. Lee, of the Bureau of Agriculture at Manila, reports that Mr. Medalla, his assistant, also visited the island and returned with specimens of the Fiji disease. Letters from both Reinking and Lee telling of the discovery reached Washington at the same time. These are the first authentic reports by pathologists of the presence of the Fiji disease in the Philippines. Just how widely the disease occurs in the Philippines will have to be determined, but it probably does not occur in Negros, the most important cane-producing island.

Importance of the disease.

Regarding the seriousness of this trouble, F. Muir (*Ha. Pl. Rec.*, **3**, 197, 1910) writes as follows : "The worst disease in the Fijian cane fields is one known as Fiji disease......This disease has spread over the whole island but is worst on the northern side, especially on rich soils. This disease is strongly hereditary ; when the stool looks perfectly healthy and the galls are seen on only one stalk and in very small numbers, every stalk from that root will produce diseased cane if used as 'seed'." Again H. L. Lyon ("A New Cane Disease now Epidemic in Fiji," *Ha. Pl. Rec.*, **3**, 205, 1910) writes : "It is certain that the Fiji disease is one of the most serious diseases yet recorded on sugarcane."

The report of the Experiment Station Committee of the Hawaiian Sugar Planters' Association, October 14, 1911, says (*Ha. Pl. Rec.*, **5**, 323, 1911) : "Dr. Lyon's researches say that the so-called Fiji disease is the most to be dreaded of all known maladies of the sugarcane." In Mr. Reinking's letter he says : "The disease is one of the most destructive plant diseases that I have ever observed in the Philippine Islands." In view of the above quotations and also from other reports on the importance of this disease, it seems that this is one of the most serious of sugarcane diseases and one to be feared in sugar areas where the disease does not now occur.

Symptoms.

Mr. F. Muir (*l. c.*) states that the most constant symptom of the disease as pointed out to him by Mr. North, of the Sugar Refinery Company, is the presence of small galls on the undersides of the leaves and in the softer tissues of the cane tops, sometimes extending a long way down the stalk. A more noticeable character is the dying of the tops and the growth of lateral branches, the tops of which also sometimes die, and, in turn, give off lateral growths.

H. L. Lyon (*Ha. Pl. Rec.*, **4**, 300, 1911) describes the disease as follows : "The most conspicuous symptom of the Fiji disease to be noted in the field is the shortening and crumpling of the first leaves to unfold from the spindle. This peculiarity will attract

the attention when one is still a considerable distance from the affected cane. The shoot may have attained considerable length and be clothed with many healthy-looking leaves of the usual colour and length, but all of a sudden it loses the power to produce normal leaves, throws out a few bent and twisted stems and then ceases to grow altogether. Some of the eyes may start, but the resulting 'lalas' soon repeat the antics of the main stem. The stalk may remain alive for months or it may soon die." He also mentions the characteristic galls usually to be found on most of the healthy-looking leaves and all of the deformed and blighted leaves. The appearance of these galls is the first outward symptom by which the disease may be detected, but the cane may be infected for months before any galls appear. In other words, the galls mark a well advanced stage of the disease. According to Lyon's photographs, affected plants are very much stunted and dwarfed and die early.

CAUSE.

The Fiji disease is apparently caused by a Myxomycete somewhat similar to *Plasmodiophora brassicæ*, the cause of the club root of cabbage. A study of the etiology of the disease was made by H. L. Lyon and a preliminary report given out by him (*Ha. Pl. Rec.*, **3**, 200–205, 1910). Lyon found what appeared to be the plasmodium of an organism in the cells of the leaf galls but apparently has not proved the pathogenicity of such organism. He thinks that the swarm spores may gain entrance to the cane tissue by penetrating the roots and then following up the vascular bundles to the leaves. He also thinks that the organism can live over in the soil for a considerable length of time, as does the organism of club root of cabbage. Plants grown from cuttings taken from diseased cane are sure to be infected. The organism is also readily carried from field to field by the transfer of bits of trash.

VARIETAL SUSCEPTIBILITY.

According to Lyon and Muir, the disease shows marked difference in varietal susceptibility in Fiji and New Guinea. On

account of this fact and because of the danger of the appearance of the disease in Hawaii, the Hawaiian Sugar Planters' Experiment Station sent a large number of cuttings of various Hawaiian varieties to Fiji to be propagated there and to ascertain their relative resistance to the Fiji disease.

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OUTBREAK OF A CURIOUS DISEASE AMONGST POULTRY.

It may interest poultry breeders in India, and perhaps more especially in the Punjab, to note that a peculiarly fatal disease has appeared amongst fowls in Lahore. The information is, of necessity, somewhat vague, as only one outbreak has occurred up to the time of writing (February 1921), and in that most of the fowls died so suddenly that a thorough examination, such as the writers would wish, could not be carried out.

The symptoms displayed are those of "Limberneck," a fowl disease very prevalent and well known in America, and are briefly as follows :—

The first symptoms are those of lack of co-ordination with a slightly staggering gait. Later, the fowl attempts to preserve its balance by assuming a curiously upright position. At this stage when persuaded to move, it lifts its feet abnormally high and gives one the impression it is attempting to "goose step." The loss of co-ordination increases until complete, when the bird appears almost paralysed. Death ensues soon afterwards.

The time which elapses between the first appearance of symptoms and death varies in individual cases from one to eight days.

The birds attempt to eat throughout the period of illness until the time of death.

From the above brief account it will be seen that the symptoms closely resemble those found in fowls suffering from a "deficiency disease," but the diet which the fowls were receiving eliminates any possible chance of the latter. The etiology of the disease is at present obscure. Post-mortem examinations failed to reveal anything of a pathogenic nature.

Emulsions of the brains and spinal cords of the diseased fowls were made and injected subcutaneously and intra-spinally into healthy fowls and rabbits, but failed to convey the disease. Microscopic examinations of the blood, brain and spinal cord were negative. A curious fact, and one well worthy of note, is that the pen consisted of twenty-five English birds and twenty-five country-breds. All the twenty-five English birds became affected, twenty-three of which died. None of the country-breds contracted the disease.

All the birds were housed together and lived under identically similar conditions.

The writers regret that, at the present juncture, they cannot offer any advice as regards specific treatment of the disease, but would suggest that, at the outset of an outbreak, the healthy fowls should be at once taken away from the pen and kept elsewhere. When more material is obtainable, more work will be done and, it is hoped, a more definite statement will be made on it.

The accompanying photographs (Plate XXIII) illustrate the different positions during the disease. [W. TAYLOR and E. SEWELL.]

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RETARDED DEVELOPMENT OF TEMPERATE CEREAL VARIETIES UNDER TROPICAL CONDITIONS.

SUCH cereal grains as wheat, oats and barley are commonly considered cool temperature crops. Cool seasons favour their production while warm seasons retard it.

Walster[1] has carried on an interesting series of experiments which throw new light on this subject. He grew barley from the germination stage to maturity in two greenhouses kept at uniform but different temperatures. Different cultures were kept in nutrient solutions of varying strengths in order to show a possible correlation between the temperature and the chemical content. He found that while the plants in the warm house (20° C.) germinated most

[1] Walster, H. L. "Formative effect of high and low temperatures upon the growth of barley : a chemical correlation." *Bot. Gaz.*, 69, 97–126, 1920.

Fig. 1. Front View.

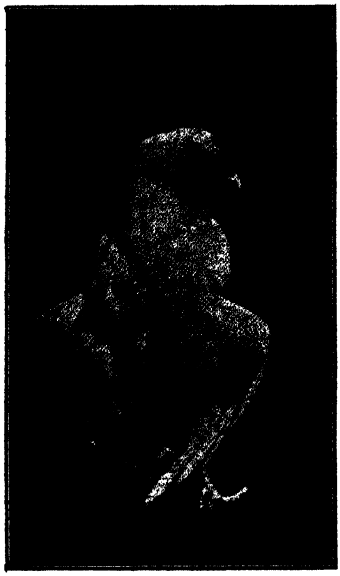

Fig. 2. Back View.

Fig. 3. Attitude while feeding.

Fig. 4. Characteristic position just before death.

CURIOUS DISEASE AMONGST POULTRY IN LAHORE.

rapidly and made the most rapid growth for the first two weeks, those in the cool house (15° C.) had outstripped them after six weeks, and came into maturity more quickly. This result was especially marked in those pots with nutrients of high nitrogen content.

One of the striking results of high temperature with high nitrogen supply is the great dominance of leaves over culms. A jar of plants under these conditions consisted by actual weight of 92·95 per cent. leaves to 7·05 per cent. stems, while a jar of plants with the same high nitrogen supply but grown at a low temperature consisted of 69·20 per cent. leaves and 30·80 per cent. stems. Another conspicuous result was the tendency of the leaves under high temperature conditions to lop or sprawl, as if too weak to stand in the normal position.

As the cultures approached maturity the difference became even more striking, inasmuch as while the plants in the cool greenhouse underwent the normal development, those in the warm greenhouse were much belated. Indeed, the author thinks that in the latter situation, with high nitrogen, the vegetative condition would have continued indefinitely if the water supply had been kept uniform. The tardy and feeble development of flowering culms which did occur he attributes to a decrease in the water supply.

Varying temperatures at germination and early growth alters the chemical equilibrium within the plant in such a way as to prevent the normal tendency towards reproduction. Chemical analyses of the plants grown show the validity of the following equations :

High heat supply + high nitrogen supply in nutrient solution = high soluble nitrogen in leaf + low soluble carbohydrate = excessive vegetation and little culm formation.

Low heat supply + high nitrogen supply in nutrient solution = low soluble nitrogen in leaf + high soluble carbohydrate = normal vegetation and normal culm formation.

This work throws interesting light on the experience of the reviewer a year ago in the attempt to grow American wheat seed on the grounds of the Allahabad Agricultural Institute.

Seed of Kanred wheat, one of the best varieties now grown in Kansas, which is the leading winter wheat State of the Mississippi valley, were planted in test plots, in river silt alongside of similar plots of the Pusa and Cawnpore varieties. It made a luxuriant leafy growth, showing no sign of culm formation, while the adjoining plots were undergoing their usual development. The sprawling of the outer leaves was noticeable in these dwarf but abnormally leafy and intensely green plants. About May 1, after the other wheat had ripened and had been harvested, and as the soil became very dry, the Kanred wheat, still green, made feeble culms, not a foot in height, bearing small heads which did not fill out well.

Photograph taken about 10th May, 1920, showing belated reproductive activity of Kanred wheat from American grown seed. At the left is a shock of ripened and cut Pusa 12 wheat which has been placed here for comparison.

Dr. H. M. Leake states that he has observed similar behaviour in Cawnpore on the part of wheat varieties introduced from the Himalayas. During the greater part of the season they presented an appearance more suggestive of lawn grass than of wheat.

Feeble culm development and belated reproduction was also noted by the reviewer, but in a less striking degree, during the

winter of 1920–21 in Mariout barley, the seed of which was sent from California. His attention has frequently been called to peculiar and erratic development of vegetables from northern grown seeds. Complicated and interesting physiological problems are involved in these phenomena, the solution of which will necessitate the growing of such seeds under careful temperature control. [L. A. KENOYER.]

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PROGRESS OF FLAX INDUSTRY IN KENYA.

DURING the war, with the foreign supplies cut off, the position as regards flax in Great Britain gave cause for great anxiety. Belgium and Northern France were the first of the flax-producing countries to suffer, while Russia, which before the war supplied 80 per cent. of the world's flax, finally went entirely out of the market. Great efforts were made in Britain to increase the area under the crop and though these were successful up to a point, the demand for flax as a munition of war could not be met. Attention was therefore turned to those outlying parts of the Empire where conditions suitable for flax-growing existed. An interim report on the progress of the flax industry recently issued by the Director of Agriculture in Kenya Colony (British East Africa) shows that though immediate needs were not actually met, great progress has been made in flax-growing since hostilities ceased. In 1918, 8,000–9,000 acres were under flax, but this area had increased to 25,000 acres in 1920, the total value of the crop amounting to £450,000. At the end of June 1920, 68 mills with 1,252 scutching wheels were either in working order or in course of erection.

Although the quality of the flax grown has been judged by experts as comparing favourably with " high-class European flaxes," the Agricultural Department is not unmindful of possible improvements. Variety trials and experiments with different methods of retting are in progress and the results have been valuable and instructive. The growers appear to be inexperienced and do not yet seem to have realized the necessity of a rotation in flax-growing. Present indications point to the higher altitudes with their colder

climate and heavier rainfall as being the best suited for flax-growing. The local supply of seed is now quite sufficient and such importations as will now be made should consist only of new varieties or strains. The only disease affecting this crop is described as "wilt," but it is not anticipated that it will be responsible for much loss provided good farming principles are observed. An enemy of much more serious consequence appears to be the "flax caterpillar," but fortunately an appliance appears to have been invented by which the caterpillar can be removed at comparatively little expense.

Present methods of marketing are expensive, and the question of establishing one or more central flax markets in the colony is not being lost sight of. A Flax Association has already been formed, and one of its first acts has been to agree to the introduction of a system of flax grading which will be in charge of two officers of the Agricultural Department. [EDITOR.]

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REPORT OF THE COUNCIL OF THE LINEN INDUSTRY RESEARCH ASSOCIATION FOR 1920.

THIS Association became an incorporated body in September 1919, and derives its funds partly from subscriptions and guarantees and partly from the Department of Scientific and Industrial Research, the total income for the year being slightly over £12,000. The Association has now purchased the Glenmore House Estate near Belfast and is raising a fund of £25,000 to cover the cost of purchase and equipment. The Director is Dr. J. Vargas Eyre, recently of the Flax Production Branch of the English Ministry of Agriculture, and the following research programme has been adopted :—

1. The selection and breeding of improved strains of flax seed for sowing purposes.
2. An investigation of the apparent need of frequent changes of seed for sowing purposes.
3. Variety trials and manurial trials.
4. The commercial and industrial value of oil from immature flax seed,

5. Study of the behaviour of fibres from diseased and dead straws.
6. Investigation of the difference in the behaviour of flax when water-retted and dew-retted, and thereafter in spinning, bleaching, and weaving.
7. Problems presented by the introduction of substances into the spinning troughs, and the possible advantage of so doing.
8. Investigation into the preparing and spinning processes, with a view to securing uniformity of yarn.
9. Investigation into the winding and warping, with a view to uniformity of tension.
10. Investigation into the methods of drying yarns.
11. Study of the sizing and finishing of yarns, threads, and twines.
12. Investigation regarding mechanical weaving.
13. Investigation into the dyeing of linen yarns, threads, and cloth.
14. Study of the avoidance of waste.
15. Investigation of the utilization of by-products.
16. Investigation into the use of suitable lubricants.
17. Investigation into the finishing of cloth.
18. The study and indexing of all literature and patents.
19. Scientific costing.
20. Study of similar problems in connection with the industrial use of hemp and ramie, either alone or in conjunction with flax.

An interesting feature of the organization is a series of standing committees to discuss with the Director and his staff questions arising during the course of research work bearing on particular branches of the industry. The Joint Standing Agricultural Committee includes two representatives of the Council and one representative each from the Agricultural Departments of England, Scotland and Ireland. Other Committees are the Research Committee, Publication Committee, Agricultural and Raw Material Sub-committee, Spinning Sub-committee, Weaving Sub-committee,

Bleaching and Dyeing Sub-committee, Sizing and Finishing Sub-committee, and Costing Sub-committee. The Research Committee receives and considers, on behalf of the Council, the Director's quarterly report embodying the results of the research activities and the proceedings of the Research Sub-committees. [B. C. Burt.]

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STEAM PLOUGHS OR TRACTORS.

A Correspondent writes in "The Times" Trade Supplement, dated 23rd April, 1921:—

There is a good deal of controversy at the moment as to the respective merits of the steam cable sets and the internal-combustion direct ploughing tractors, and followers of the rival methods are anxious to promote competitive tests.

The view of the general body of agricultural engineers, however, is that steam ploughs and tractors are not really in competition with one another. The former are admittedly unexcelled for large areas, especially where deep cultivation on heavy, resisting clays has to be carried out, or where, as in many sub-tropical countries, large areas of hard, unbroken soil have to be made available for sugarcane, rubber plantations, etc. British steam ploughs are unequalled for efficiency, and there are practically no foreign competitors in this line, the demand for which, though slow at the moment owing to exchange difficulties, is usually world-wide. Steam ploughs, though costly at first, are generally admitted to be the most economical form of cultivating when the estates are large enough to provide full-time employment for them.

On the other hand, the tractor is really the farmer's own machine rather than a contractor's unit, and its capacity to plough an acre to a depth of five or six inches on less than three gallons of paraffin makes it more economical than horses, while at the same time ensuring that the farmer will "catch the season" for his ploughing, cultivating, and harrowing. Tractors are also very useful in harvest, for their small overall dimensions render them handy enough to haul a binder. The tractor trade, however, has

suffered at home from the " open " season, and makers are looking to the foreign markets to make up the demand.

British agricultural engineers are, in fact, especially well situated to cater for oversea trade, and early improvement in the number of indents is expected. A promising development is the new cheap motor lawn-mower which is now being manufactured and for which the inquiries are very large. Hand lawn-mowers are also wanted for the Dominions, New Zealand in particular. Potato planters are another improving line, but the outlook for home-made harvesting machines is not bright..........British makers hope to reduce prices in 1922 and cannot do so much earlier owing to the heavy stocks of high-priced material they hold.

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SUGAR INDUSTRY IN BRITISH GUIANA.

WE take the following useful facts from a somewhat belated report on British Guiana for the year 1919 presented to Parliament in March 1921 :—

The total area under sugarcane in the colony was 71,500 acres during the year 1919. The sugar crop was far below the average, being 86,971 tons as compared with 102,315 tons, the average annual yield of the preceding eight years. The deficiency was caused by scarcity of labour and unfavourable seasons but principally by a scarcity of nitrogenous manure (sulphate of ammonia). Only 83,140 tons of sugar were exported during the year. The returns submitted by sugar estates in the colony showed that in 1919 more than nine-tenths of the total area under cane was planted in varieties other than the Bourbon. Only about 3,000 acres are now occupied by Bourbon unmixed with other varieties. Of the area, estimated at 65,000 acres, cultivated in new varieties, 92 per cent. was under canes raised from seed in the colony, while about 7 per cent. was occupied by varieties imported from Barbados. Of the total area under cane cultivation 78 per cent. is occupied by new varieties raised at the Georgetown Botanic Gardens.

This indicates the great importance of continuous work on evolving superior varieties of cane by raising seedlings within the

country where the varieties are to be cultivated. Work on these lines is being done in India at the Cane-breeding Station, Coimbatore, and promises to give useful results. [WYNNE SAYER.]

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CANE SUGAR: DANISH CHEMIST'S NEW PROCESS.

A YOUNG Danish scientific chemist, Mr. Schmidt, has devised a process, says the Copenhagen Correspondent of "The Morning Post," which probably will introduce great changes into the cane-sugar industry. By his new method the troublesome process of refining the sugar juice by means of lime is avoided. The juice rolled out of the canes is purified in the course of one treatment into a syrup clear as water, which is ready for evaporation into pure sugar. In Mr. Schmidt's invention the lime is replaced by an exceedingly comminuted charcoal, which is churned into the raw sugar juice, and combines with the components contained therein in a far more complete way than in the lime refining. A perfect result is obtained by filtering the product. The charcoal for the process is supplied by the combustion of the refuse product resulting from the filtering, the producing process thereby becoming continuous, as the refining of the sugar juice is effected by components contained in the juice itself.

Mr. Schmidt's invention is the result of a long series of experiments carried on in the sugar mill in Java where he is employed, and it is believed that it will greatly increase the quantity of sugar obtained from the canes, as well as simplify the producing process. [*Production and Export*, April 1921.]

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DWARF OR KING COCONUT.

RECENTLY considerable interest has been aroused in a variety of coconuts called the Dwarf or King coconut which is remarkable for its early fruiting and heavy bearing. We therefore reproduce the following note regarding this variety from the "Proceedings of the Agricultural Society of Trinidad and Tobago" for January 1921:—

The dwar fcoconut, known in the Malay Peninsula as "nyiur gading," is remarkable for its early fruiting, palms only 10 feet

high bearing abundant fruits touching the ground. The young palm, grown under good conditions, starts to flower in its third year, and produces ripe fruit in about nine months from the appearance of the flower-spike. The initial flower-spikes contain only male flowers, but other spikes occurring in rapid succession are larger and bear an increasing number of female flowers also. On a spike from a six-year-old tree 200 young female flowers have been counted, while trusses of fruit from similar trees have been found with as many as fifty-five ripe nuts.

The dwarf coconut is generally of a bright yellow colour, but there are, besides, a distinct brick-red variety, a green variety, and a number of intermediate colours which might be ranged as ivory yellow, golden yellow, orange, brick-red, green bronze, and deep green. The flower-spikes, leaf bases, and leaf ribs correspond in colour with the fruit, giving the compact trees a very handsome appearance. Again, there are semi-tall trees of these different colours, which are later in coming into bearing, having slightly larger nuts and are less prolific than the true dwarf.

The dwarf yellow strain appears to be the most prolific, whilst the other varieties vary proportionately in their productiveness, and also in the shape and size of the nut, and are evidently the outcome of cross-fertilization from original types or mutants.

A full-grown leaf of the "nyiur gading" measures only 12 feet from base to tip, whilst an average ripe nut measures $32\frac{1}{2}$ inches by 24 inches in circumference. The nut has an average amount of fibre, a thin shell, and, proportionately with the big nut, a good thickness of white kernel.

This "meat" is said by the Malays to be richer in oil and sweeter in taste than that of the big coconut, and is therefore very popular with them for domestic purposes.

In 1912, 500 acres were planted with these dwarf nuts at Sungei Nipha estate, on the coast between Port Dickson and Sepang Point, and this is probably the only estate of dwarf coconuts in the world.

In the first year of production at Sungei Nipha, the crop from over 225 acres was 102,000 nuts, while in the second year it was 574,000 nuts, and in the third year it will probably be nearly a million. From these data the average yield for dwarf nuts may be predicted as follows :—

At the end of the 4th year —	1st yielding	10 nuts per tree.	
,, ,, ,, ,, ,, 5th ,,	2nd ,,	30 ,, ,, ,,	
,, ,, ,, ,, ,, 6th ,,	3rd ,,	60 ,, ,, ,,	
,, ,, ,, ,, ,, 7th ,,	4th ,,	80 ,, ,, ,,	
,, ,, ,, ,, ,, 8th ,,	5th ,,	100 ,, ,, ,,	
,, ,, ,, ,, ,, 9th ,,	6th ,,	120 ,, ,, ,,	in full bearing.

These estimates, in face of yields from individual trees, will appear conservative, but there are many points which have to be considered when dealing with average yields, and no doubt, under ideal conditions, a much higher average could be obtained.

In making copra it has been found that the nut from a young tree is smaller than that coming later, and its kernel likewise thinner; while on heavy yielding trees the nuts are a little below the average in size; but 500 nuts to a picul (1 picul = $133\frac{1}{3}$ lb.) of copra is a general average, which would be decreased somewhat later when more even nuts with thicker meat were obtained. With a leaf length of only 12 feet, it was found convenient to plant the palms 24 feet by 20 feet, which gave ninety trees to the acre, a number nearly double that required when planting big palms.

It will be evident, therefore, that with this planting there might be obtained, say, in the fifth year of planting 90 by 30 nuts = 2,700 nuts per acre. Likewise, in the ninth year 90 by 120 = 10,800 nuts per acre. Comparing this with the big coconut, which does not produce till after its fifth year, the crop might be estimated in the ninth year as forty-five trees with forty nuts, average 1,800 nuts per acre. With the dwarf trees there is the great advantage of easy and rapid picking, and inspection for beetles and other pests, though in manufacture one has to handle almost two and a half times the number of nuts per picul of copra ; but this is not of so great consequence when working with newly devised methods and machinery for dealing with larger quantities.

PRICKLY PEAR.

"THE Journal of Industries," which is issued by the authority of the Minister of Mines of Industry of the Union of South Africa, in the September (1920) Number gives the second of the articles by Dr. Juritz on the prickly pear, and the possibility of its utilization. The author has already discussed in other publications the possibility of using the prickly pear as a source of industrial alcohol. To make alcohol production from this source profitable it would appear necessary to produce a large amount of fruit from small areas which, to make collection economic, should bear ten tons of fruit to the acre. There would also have to be devised a less expensive method of collecting than hand-picking. This question, by the way, has already been investigated in New Mexico, and the problem appears to be only one of economics. There is a possibility of certain species of prickly pears being used for the sake of a mucilaginous substance which can be obtained from it. It is also suggested as a source of oxalic acid, since crystals of calcium oxalate are contained in all parts of the plant in comparatively large proportions and some other oxalates are to be found in the liquid condition. The prickly pear is also suggested for paper-making, but the pulp, which has so far been prepared in experiments, appears to consist of short fibres which would have a low value and, as is so often the case with such plants, the yield per ton of raw material is small and the amount of re-agents required relatively great.

A dye or colouring matter of a light magenta shade can be extracted without difficulty from fruits of certain kinds of prickly pear, and this dye, from the species which occur on the high mountains of Argentina, has been used locally for dyeing wool. There is however a great deal of research necessary before recommendation for commercial venture in this field could be made. As a source of oil the great difficulty appears to be again in the collection of material, and the low percentage of oil in the seeds of the plant would appear to make it commercially impossible. The plant has also been suggested as a basis for soap manufacture, but there is nothing to indicate that this suggestion can be considered seriously. The article concludes with a number of minor uses, but such

applications as are named are not such as to encourage any commercial development. [*Scientific American Monthly*, Vol. III, No. 1.]

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THE CRISIS IN THE TEA INDUSTRY.

An authoritative article on the production of tea in the Empire and its relation to the tea trade of the world is contained in the current number (October-December, 1920) of the "Bulletin of the Imperial Institute." It deals in an interesting way with the growth of tea drinking in various parts of the world, gives particulars of the industry in all tea-producing countries and discusses the causes which have led to the present serious crisis in the industry.

India and Ceylon together produce more than two-thirds of all the tea which enters into the world's commerce, their most serious competitor at the present time being Java. At the beginning of 1919 prices in London for all grades of tea were good and stocks in the United Kingdom were not excessive, but apparently no account was taken of stocks held in producing countries. The tea trade had been disorganized by the war and by Government control, and as no danger signals, pointing to over-production, were raised, the plantations in the British and Dutch Indies in 1919 produced tea to their full capacity. The Russian market, which had been taking nearly 100,000,000 lb. of plantation tea yearly, was lost and stocks began to accumulate, until, in the middle of last year, the actual situation was realized and there was a break in prices for all the lower grades, which have since been selling below the economic value. There is no question regarding the soundness and ultimate prosperity of the tea industries of India and Ceylon, but the immediate outlook for many estates is very critical. The seriousness of the position is apparent from the fact that the plantation industry in the two countries supports at least 3,000,000 workers and their dependents.

It is thus to the common interest of both producer and consumer that the tea industry should be placed on a sound basis. The most serious obstacle however to the return of more healthy trade

conditions is the great accumulation of stocks of common teas. In the absence of a demand from Russia there appears to be little prospect, in the immediate future, of reducing the volume of these stocks, but unless this is effected, or the sales of tea regulated, there can be no recovery in prices for a long time.

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QUARANTINE ON ACCOUNT OF CITRUS BLACK FLY (*ALEUROCANTHUS WOGLUMI*, ASHBY).

WITH a view to prevent the introduction of the Citrus Black Fly into the United States of America, the importation or entry into the States, from India, Cuba, the Bahamas, Jamaica, Canal Zone, Costa Rica, Philippine Islands, Ceylon and Java, of fruits and vegetables in the raw or unprocessed state and of plants or portions of plants used as packing material in connection with shipments of such fruits and vegetables, or otherwise, has been forbidden except under permit.

PERSONAL NOTES, APPOINTMENTS AND TRANSFERS, MEETINGS AND CONFERENCES, ETC.

We deeply regret to learn of the death in London on 6th June, 1921, of Major A. W. Slater, V.D., Managing Director of the Calcutta Phototype Company.

The late Major Slater was in charge of the reproduction of plates for the publications of the Imperial Department of Agriculture, and the "Agricultural Journal of India" and other publications issued from Pusa owe much to his efforts. He was a pioneer in this country of the three-colour process printing, and always kept himself in touch with the latest developments in the art of reproduction. Major Slater did much to facilitate the publication of scientific work in India, and his premature death will be widely felt in scientific circles.

His Majesty the King-Emperor's Birthday Honours List contains the following names which will be of interest to the Agricultural Department:—

K.C.I.E. Mr. Evan Maconochie, C.S.I., I.C.S., Agent to the Governor in Kathiawar, Bombay (sometime Under-Secretary to the Government of India, Revenue and Agriculture Department).

C.S.I. Mr. C. A. Innes, C.I.E., I.C.S., Secretary to the Government of India, Commerce Department (sometime Under-Secretary to the Government of India, Revenue and Agriculture Department).

MR. W. R. GOURLAY, C.I.E., I.C.S., Private Secretary to His Excellency the Governor of Bengal (sometime Director of Agriculture, Bengal).

Khan Bahadur. KHAN SAHIB SAYAD SARDAR SHAH GILANI, Professor of Bovine Pathology, Punjab Veterinary College, Lahore.

Rao Bahadur. M. R. RY. J. CHELVARANGA RAJU GARU, Deputy Director of Agriculture in the Madras Presidency.

Sardar Sahib. BHAI KHARAK SINGH, Assistant Professor of Agriculture, Agricultural College, Lyallpur.

Khan Sahib. MR. N. D. DHAKMARVALA, G.B.V.C., First Professor, Veterinary College, Bombay.

MUNSHI ABDUL QAYUM, Warden to the Agricultural College, Cawnpore.

Rai Sahib. BABU JAMINI KUMAR BISWAS, Superintendent of Agriculture, Dacca.

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MR. W. A. POOL, M.R.C.V.S., Offg. Second Bacteriologist, Imperial Bacteriological Laboratory, Muktesar, is appointed to officiate as Director and First Bacteriologist, in addition to his own duties.

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MR. T. M. TIMONEY, M.R.C.V.S., has been appointed to the Indian Civil Veterinary Department and posted to the Imperial Bacteriological Laboratory, Muktesar, as Third Bacteriologist.

***

DR. W. BURNS, Economic Botanist to the Government of Bombay, is granted combined leave for one year with effect from the 1st October, 1921.

***

MR. P. C. PATIL, L. AG., Deputy Director of Agriculture, Central Division, Bombay, is allowed combined leave for one year from the 1st July, 1921.

RAO SAHEB M. L. KULKARNI is appointed to officiate as Deputy Director of Agriculture, Central Division, Bombay, *vice* Mr. Patil on leave.

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KHAN SAHEB J. D. BUXY has been appointed to act as Superintendent, Civil Veterinary Department, Bombay, *vice* Mr. G. Taylor, M.R.C.V.S., proceeding on leave.

***

MR. K. McLEAN, B.Sc., Deputy Director of Agriculture, Eastern Circle, Bengal, is appointed to act as Fibre Expert to the Government of Bengal, *vice* Mr. Finlow on leave.

***

MR. F. SMITH, B.Sc., Deputy Director of Agriculture, Western Circle, Bengal, has been transferred to Dacca to hold charge of the Eastern Circle.

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RAI RAJESWAR DAS GUPTA BAHADUR, Deputy Director of Agriculture, Northern Circle, Bengal, is posted to Calcutta to hold charge of the Western Circle.

***

MR. P. C. CHAUDHURI, Superintendent of Sericulture, is appointed to act as Deputy Director of Sericulture, Bengal, rom the 3rd June, 1921, until further orders.

***

MR. E. BALLARD, B.A., is confirmed as Government Entomologist, Madras, in the Indian Agricultural Service.

***

MR. D. QUINLAN, M.R.C.V.S., Superintendent, Civil Veterinary Department and Veterinary Adviser to the Government of Bihar and Orissa, has been granted combined leave for eight months, Captain P. B. Riley officiating.

***

MR. T. R. LOW, Deputy Director of Agriculture, United Provinces, has been appointed to hold charge of the Central Circle, Cawnpore, *vice* Mr. B. C. Burt, M.B.E., B.Sc., appointed Secretary, Central Cotton Committee.

MR. W. YOUNGMAN, B.Sc., Economic Botanist to Government, United Provinces, has been granted combined leave for seven months and 17 days, Mr. P. K. Dey, Plant Pathologist, holding charge of the current duties of the Economic Botanist, in addition to his own.

***

MR. B. H. WILSDON, B.A., Agricultural Chemist to Government, Punjab, has been granted combined leave for eight months, Dr. P. E. Lander officiating.

***

MR. W. ROBERTS, B.Sc., Principal and Professor of Agriculture, Agricultural College, Lyallpur, has resigned from the Indian Agricultural Service.

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MR. D. MILNE, B.Sc., Economic Botanist to Government, Punjab, Lyallpur, has been appointed Principal of the Agricultural College, Lyallpur.

***

MR. W. TAYLOR, M.R.C.V.S., Professor of Pathology and Parasitology, Punjab Veterinary College, Lahore, has been appointed Post-Graduate Professor, in addition to his own duties, relieving Captain E. Sewell, M.C., M.R.C.V.S., who has been deputed to the Government Cattle Farm, Hissar, for carrying out feeding experiments on cattle.

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THE headquarters of MR. T. D. STOCK, Economic Botanist, Burma, have been transferred from Mandalay to Myingyan.

***

MR. S. G. MUTKEKAR, who has been appointed to the Indian Agricultural Service as Assistant Director of Agriculture, has been posted to the Western Circle of the Central Provinces with headquarters at Nagpur.

MR. J. C. McDOUGALL, Assistant Director of Agriculture, has been transferred from the Western Circle to the Southern Circle of the Central Provinces.

***

MR. C. W. WILSON, M.R.C.V.S., Superintendent, Civil Veterinary Department, Central Provinces, has been appointed Veterinary Adviser to Government, Central Provinces, in addition to his own duties, with effect from 10th May, 1921.

***

MR. J. N. CHAKRAVARTI, Deputy Director of Agriculture, Surma Valley, Assam, is allowed privilege leave for six months, Srijut Laksheswar Barthakur officiating.

Reviews

Green Tea.—By CHAS. JUDGE. (Calcutta and Simla : Thacker, Spink & Co.) Price, Rs. 2.

WE have read with considerable interest the pamphlet entitled "Green Tea" by Chas. Judge. It gives a concise but clear exposition of the practical methods for the preparation of green tea, and whilst it gives an account of the manner in which the process should be carried out in an essentially practical manner it does not overlook the scientific reasons for various processes. The method advocated of dealing with the green broken tea affords a very good example of the practical application of scientific principles to the solution of practical problems. Mr. Judge seems to have studied the question of green tea manufacture thoroughly and he has been able successfully to incorporate this knowledge in a pamphlet. [P. H. C.]

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A Naturalist in Himalaya.—By Captain R. W. F. HINGSTON, M.C., I.M.S. Pages xii+300+25 illustr. (London : Witherby & Co., 1920.) Price, 18*s*. net.

THIS book deals with miscellaneous observations carried out in the Hazara District, and contains numerous interesting notes on insects and insect-life. Thus, Chapter II deals with Harvesting Ants, and the next chapter with their senses and instincts, whilst Chapter IV treats of Carnivorous Ants and Chapter V with Communicating and other Ants. Chapters X—XII contain observations on miscellaneous insects, wasps, bees, butterflies, Cicadas, and termites, in the course of which the author describes and figures the vocal organs of the male of *Platylomia brevis*, a Cicadid common in the Himalayan region.

The whole book is extremely interesting and well repays perusal by all who are interested in Entomology in India. [T. B. F.]

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An Introduction to Entomology.—By J. H. COMSTOCK. Second Edition. Pages xviii+220+220 figs. (Comstock Publishing Co., Ithaca, N.Y., 1920.) Price $ 2·50.

THIS publication constitutes Part I of a general Text-book of Entomology under preparation by the author, and deals briefly with the structure and metamorphosis of insects. The external and internal anatomy are dealt with at as much length as can be expected in a book which only purports to serve as an introduction to this study, and we can only hope that the present publication will receive so warm a welcome that the author will be induced to supply us with a still more detailed monograph on the subject at a later date, as there is a decided want for a work in the English language on the same line as Berlese's *Gli Insetti*. Meanwhile the present *Introduction* will be found indispensable to all serious workers on the subject. [T. B. F.]

Correspondence

INFLUENCE OF STOCK ON SCION.

To the Editor,

The Agricultural Journal of India.

Sir,

With reference to Mr. Furtado's letter on the influence of stock on scion in your Journal (Vol. XVI, Part II, page 226), I beg to offer the following remarks.

In my private gardens at Bassein, Thana District, on the Bombay coast, I had one row of *chiku* (*Achras sapota*) consisting of seven plants. Of these, there was one plant worked on *Mimusops hexandra* stock, and of the rest two plants were propagated by *gootee* (marcotte) and the rest grafted on *chiku* stock ; among these were included the so-called prolific and shy bearing varieties of *chiku.*

After planting, when they grew well and began to bear, it was continuously observed for years that the plant worked on *Mimusops* stock did not give even one-third the number of fruits produced by those worked on *chiku* stocks.

From the *chiku* plant worked on *Mimusops* stock scions were taken and worked on *chiku* stocks. At the same time scions from ordinary *chiku* plants were worked on *chiku* stocks. These plants were planted. The bearing of these plants was marked for some years, and it was found that there was no difference in their yielding.

It will thus be seen that the trees worked on *Mimusops* stocks are shy bearers.

Bassia latifolia and *Calophyllum inophyllum* are also used as stocks for *chiku* by some nursery-men, but I have no figures of yield from plants so grafted.

Regarding the grafting of the Anacardiaceæ, I may say that I have repeatedly tried at Bassein to graft mango scions on *Anacardium occidentale*, always meeting with failure. I have no experience of grafting the mango on *Spondias* species.

If Mr. Furtado will get a few grafts of mango worked on *Spondias mangifera* and *Anacardium occidentale*, I shall be pleased to purchase two of each for trial.

I note Mr. Furtado's remarks regarding the influence of climates on the success or failure of graftings. I think that the evidence on that point is yet far from complete, and we may look on Mr. Furtado's statement as an opinion and not a proved fact for the present.

May I bring to the notice of the botanists that the *Calophyllum*, which is grouped among the Guttiferæ, unites with the distinct group of plant Sapotaceæ, when grafted, and that plants of one natural order, *Anacardium* and *mangifera*, do not unite when grafted.

GANESHKIND, KIRKEE : Yours truly,

25th May, 1921. P. G. JOSHI.

NEW BOOKS

ON AGRICULTURE AND ALLIED SUBJECTS

1. TEXT-book of Land Drainage, by Joseph A. Jeffery. (Rural Text-book Series.) Pp. xx + 256. (London: Macmillan & Co.) Price 10*s*. 6*d*. net.
2. Management of Dairy Plants, by Prof. M. Mortensen. Pp. xvi + 358. (London : Macmillan & Co.) Price 12*s*. 6*d*. net.
3. Insect Pests and Fungus Diseases of Fruit and Hops, by Percival J. Fryer. (Cambridge University Press.) Price 26*s*. net.
4. Practical Dairying, by D. G. Saker. Pp. 130. (London: Methuen & Co.) Price 6*s*.
5. The Handy Book on Pruning, Grafting and Budding, by J. Udale. Pp. 146. (London : W. H. Smith.) Price 2*s*. 6*d*.
6. Vocational Chemistry for Students of Agriculture and Home Economics, by Prof. John J. Willaman. (Farm Life Text Series.) Pp. ix + 294. (Philadelphia and London : J. B. Lippincott Co.) Price 8*s*. 6*d*. net.
7. Agricultural Economics, by Prof. James E. Boyle (College Texts : Agriculture.) Pp. ix + 448. (Philadelphia, Chicago, and London : J. B. Lippincott Co.) Price 12*s*. 6*d*. net.
8. A Treatise on Manures, by A. B. Griffiths. (London: Whitacker & Co.) Price 7*s*. 6*d*.
9. Agricultural Meteorology. The Effect of Weather on Crops, by J. Warren Smith. (Rural Text-book Series.) Pp. xxiv +304 + viii plates. (London : Macmillan & Co.) Price 13*s*. net.

10. A Text-book of Inorganic Chemistry for University Students, by Prof. J. R. Partington. Pp. xii + 1062. (London: Macmillan & Co.) Price 25*s.* net.
11. Sweet Potato, by T. E. Hand and K. L. Cokerham. (Rural Science Series.) (London: Macmillan & Co.) Price 16*s.* net.
12. Agricultural Economics, by Edwin J. Nourse. Pp. xxvi + 896. (Cambridge University Press.) Price 26*s.* net.

THE following publications have been issued by the Imperial Department of Agriculture since our last issue:—

Memoirs.

1. Studies in Soil Moisture, Pt. I, by B. H. Wilsdon, B.A. (Oxon.), I.E.S. (Chemical Series, Vol. VI, No. 3.) Price R. 1-8 or 2*s.*
2. The Virulence of Tubercle Bacilli isolated from Bovine Lesions in India, by A. L. Sheather, B.Sc., M.R.C.V.S. (Veterinary Series, Vol. III, No. 2.) Price R. 1-4 or 1*s.* 8*d.*
3. Bovine Lymphangitis, by A. L. Sheather, B.Sc., M.R.C.V.S. (Veterinary Series, Vol. III, No. 3.) Price R. 1-8 or 2*s.*

Bulletin.

4. A Survey of the Indian Poppy-growing Districts for Morphine Content of the Opium produced, by H. E. Annett, D.Sc., F.I.C., M.S.E.A.C., Hari Das Sen, M.Sc., and Har Dayal Singh, B.Sc. (Bulletin No. 116.) Price As. 2.

Report.

5. Proceedings of the Second Meeting of Agricultural Chemists and Bacteriologists, held at Pusa on 7th February, 1921, and following days. Price As. 10.

THE PARADISE FLYCATCHER (*TERPSIPHONE PARADISI*).

Original Articles

SOME COMMON INDIAN BIRDS.

No. 11. THE PARADISE FLYCATCHER (*TERPSIPHONE PARADISI*).

BY

T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S.,
Imperial Entomologist ;

AND

C. M. INGLIS, M.B.O.U., F.E.S., F.Z.S.

THE Paradise Flycatcher is probably one of the most striking of the birds that occur in India and is easily recognizable, at least in the case of the adult male, by the two extremely long tail-feathers which in some localities have earned their owner the name of Ribbon-bird.

The Flycatchers form a group of birds feeding mainly on insects which are caught on the wing, the species of this group having very feeble feet, which incapacitates them from walking on the ground, their usual habit being to wait on some convenient branch and swoop down on their insect prey, which is taken in the air. Many other birds, such as the King Crow described in our last paper, also have this habit, so that we must not be taken to mean that every bird seen swooping down on an insect in the air is necessarily a Flycatcher. This group of birds is characterized by the presence of numerous long hairs stretching from the forehead over the nostrils, these hairs lying horizontally and reaching in all cases beyond the nostrils and sometimes nearly to the end of the bill. Over fifty species of Flycatcher occur within Indian limits and amongst these

the genus *Terpsiphone* is distinguishable by its crested head in conjunction with a tail as long as, or longer than, the wing. Three species of *Terpsiphone* are recorded in the *Fauna* volume on Birds, and of these *T. paradisi* is recognizable by its long and pointed crest, reaching to the upper part of the back, whilst the crest is short and rounded, not reaching beyond the nape, in the case of the Burmese Paradise Flycatcher (*T. affinis*), which occurs from Sikkim and North-East Assam to Tenasserim, and in the Nicobar Paradise Flycatcher (*T. nicobarica*), which replaces the other two species in the Andamans and Nicobars.

The Paradise Flycatcher occurs throughout the whole of the Indian Region from Afghanistan and Kashmir to Ceylon, but in the North-East, eastwards of the Brahmaputra, it is replaced by the Burmese species. It is found in most localities in the Plains throughout the year but appears to migrate locally to some extent, although there seem to be few exact records on this point; thus, Oates states that it seems to be everywhere a permanent resident, whilst Dewar says that it visits the Punjab in great numbers in summer for nesting purposes. We agree with Dewar that this bird does undergo a certain amount of local migration. In North Bihar, for example, it arrives about the end of March and leaves at the end of October, not being noticed during the cold weather. It is fairly common locally in Bihar. So far as our experience goes, the Paradise Flycatcher seems to occur most commonly in Northern India. In Calcutta it can hardly be called common, but stray specimens may be seen in gardens at all times of the year, and the same remark applies to Southern India.

The Paradise Flycatcher when young is chestnut in colour, except for a black head and crest and whitish under-parts, and the female retains this coloration throughout her life. The cock bird, however, undergoes a very striking change of appearance, the two median tail-feathers growing to a length of sixteen inches (*i.e.*, four times the length of the other tail-feathers) after the autumn moult of the second year, these long feathers being retained until the following summer, when they are cast. After the third autumn moult, these long feathers grow again and the plumage gradually

begins to turn white (with the exception of the feathers of the head and crest, which remain black), the wings and tail being the first portions to be affected by the change ; the adult male bird is thus partly chestnut and partly white for a time, and it is not until after the moult of the fourth autumn that the plumage of the body and tail becomes wholly white. Thereafter he remains white, with a black head and crest, and the two long white tail-feathers, looking like white ribbons, for the rest of his life, and is a most striking object when seen on the wing. As Cunningham says, " the first sight of one of them, floating softly along and seeming to swim through the air in a series of gentle impulses, gives rise to a very lasting mental impression. As one of the mature male birds flies along through the leafy coverts, in which they are most at home, the snowy whiteness of his long waving train gleams out in the light of the scattered sunbeams that struggle downward through the branches, and produces effects quite unlike those that attend the flight of any other kind of bird......Even in their first dress, and before they have acquired their wonderful trains, they are strikingly beautiful. They have such full, bright, black eyes, such rich chestnut tints in the wings and tail, contrasting with the shining black of the head and the snowy white of their underclothing, and their movements are so exceptionally graceful that it is hard to cease from watching them, and when they are in all the glory of full dress, they must be to every one a source of wondering admiration as they leap lightly about from twig to twig and float hither and thither among the branches."

Oates writes that the notes of the birds of this genus are very harsh, but such a statement seems decidedly libellous and once again we cannot do better than quote Cunningham, who says that " whilst travelling about over the boughs, they continually utter twittering notes, with occasional louder calls, so like those of the Blue Flycatcher that, until the birds come into view, it is impossible to make out which species one is listening to. Now and then, too, the male birds break out into sweet little songs. They are very lively and cheerful birds, always on the move ; and the males constantly flirt their great trains about, separating and closing and

undulating the long, trailing plumes in a wonderful way." The Indian name of *Shah Bulbul* also presumably indicates that this bird is by no means devoid of song. This bird does, however, at times (generally when on the wing) utter a decidedly harsh note.

All Flycatchers are insectivorous as a general rule, although some species take fruits, berries and seeds occasionally. The Paradise Flycatcher feeds on small beetles, flies, bugs, ants and spiders, as recorded by Messrs. Mason and d'Abreu from examination of actual stomach-contents. It is, therefore, together with the other species of this group, a useful bird to the agriculturist and its utility and beauty fully deserve the protection accorded to it by the Law in Bengal, Bombay and Burma (but not in other Provinces, apparently). In Mysore also it is presumably protected as being a bird of bright-coloured plumage.

The Paradise Flycatcher lays its eggs in May, June and July. The nest is usually a delicate little cup, never very deep and often quite shallow, composed, according to materials locally available, of moss, moss roots, vegetable fibres and fine grass, this last generally constituting the greater portion of the thin frame-work, which is bound around externally with cobwebs. The egg-cavity is from 2 to $2\frac{3}{4}$ inches in diameter and from one to 1·6 inches deep, and is often lined with horse-hair or fine grass. The nest is affixed to the thin branch of a tree, as a rule in a mango tree between seven and thirty (mostly between ten and twenty) feet from the ground. Three or four eggs is the normal number, the egg being a rather long oval, somewhat pointed towards one end, about 20 mm. long by 15 mm. broad, in colour pale pinkish-white to warm salmon-pink, more or less thickly speckled, chiefly at the larger end (where there is a tendency to form an irregular cap) with rather bright, but somewhat brownish-red, spots, amongst which a few tiny, pale, inky purple blotches sometimes occur. Both the parents share in the duties of incubation of the eggs and feeding of the young, the male in such cases either having or not having attained his wholly white plumage.

Our Plate gives a good idea of the male in wholly white plumage, as well as of the female and nest.

FIELD EMBANKMENTS.

BY

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THE writer feels that an apology is necessary for offering this paper for publication. He is not an engineer ; he has done little experimental work on the subject. His excuse for doing so is that he has had the opportunity of making observations in the Southern Maratha Country and South Bombay Deccan for some years, and believes that a record of his observations and opinions will be of value to those engaged in following up the investigation, and he hopes to succeed in prompting the engineer to tell the amateur experimenter where empiricism must replace a priori determinations.

The writer's thanks are due to Mr. G. R. Deshpande, Superintendent of the Dharwar farm, for help in compiling the experimental details.

The problems which field banks are called on to solve are the prevention or cure of surface erosion, and the distribution of water, and, incidental to the distribution of water, drainage.

The grower of rice on undulating land has solved the problem of water[1] distribution for himself. He constructs banks at frequent intervals along contour lines. The dry land farmer, on all but the most level land, has to face the effect of heavy rain storms on soil which is very easily washed away. He wants to prevent it being washed away and to conserve the water falling on the land. He wants to get rid of excess of water. He wants to distribute rain

[1] Keatinge, G. F. Note on Soil Denudation in the Bombay Deccan. *Proc. Bd. Agri India*, 1916, p. 52. Howard, A. *Loc. cit.*, p. 45.

water falling spasmodically, over the optimum area and the optimum time. He has made many attempts on his own account, some successful, some not, and many involving the loss of thousands of rupees worth of capital. It is his case, that of the dry land farmer on undulating black soil, where a rainfall of 10-30 inches falls mostly in short sharp showers, that is crying out for help. His own efforts and his frequent enquiries are sufficient to prove that his land is valuable enough to bear fairly heavy capital charge under this head.[1]

The cause of surface erosion, as is obvious to the most casual observer, presents many phases: from the source as a small runnel in a field to the *nalla* which slowly eats its banks away; from the slow running *nalla* on a gentle slope to the fast running stream on a steep incline; from the *nalla* which is contained within steep banks to that which periodically floods the land near its banks, sometimes with damage, sometimes with benefit. Effect varies with these phases, with the amount and distribution of the initial cause, rainfall; and the problem at any phase, whether it be in the main one of erosion or water distribution, or of drainage, resolves itself into control of the movements of rain water. Erosion may have only attained its early stages, it may have advanced to the stage of complete denudation. Rainfall may be so small that it is necessary to concentrate it on an area much smaller than the total catchment; it may be large enough to aim at even distribution over its whole catchment area, or it may be so large that there is a surplus after such even distribution. Classification[2] of the problems can then only be purely arbitrary, and benefits to be derived from such classification doubtful. The establishment of general principles on which individual calculations can be based is required.

Take an example. Diagram I shows a common remedy adopted in a common situation. The "band" is of black soil, on a black soil foundation; the waste weir is of masonry, or of loose stones built up without mortar; it may have a firm foundation, it probably has not: its position has been decided by guess-work. The result is the creation

[1] Keatinge, G. F. *Loc. cit.*, p. 56.
[2] Keatinge, G. F. *Loc. cit.*, p. 54.

of a tank whose water may evaporate in time to sow a cold weather crop, may do so only partially, and may result in salt efflorescence.

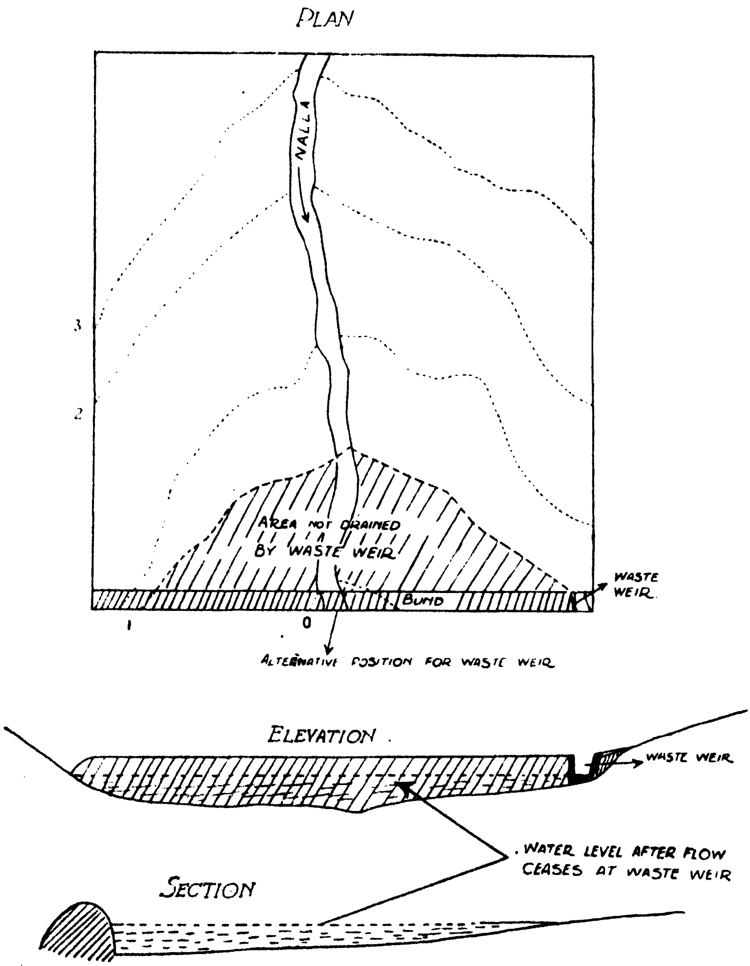

Diagram I.

Water is concentrated on a much smaller area than it might be made to serve, and in the course of years there is an unnecessarily deep accumulation of silt near the centre of the embankment, which silt might have been distributed to much better advantage. Sooner or later the bank breaches, sometimes early, before any benefit has been derived from the investment, sometimes resulting in the loss of benefit accumulated during several years.

The cultivator has done much to remedy these defects. He plants trees, shrubs or grass on the " band." He combines a simple automatic, or hand operated sluice with his weir, so that water is held up long enough to deposit its silt. A common form of sluice is illustrated by Diagram II. A loose stone weir serves a similar

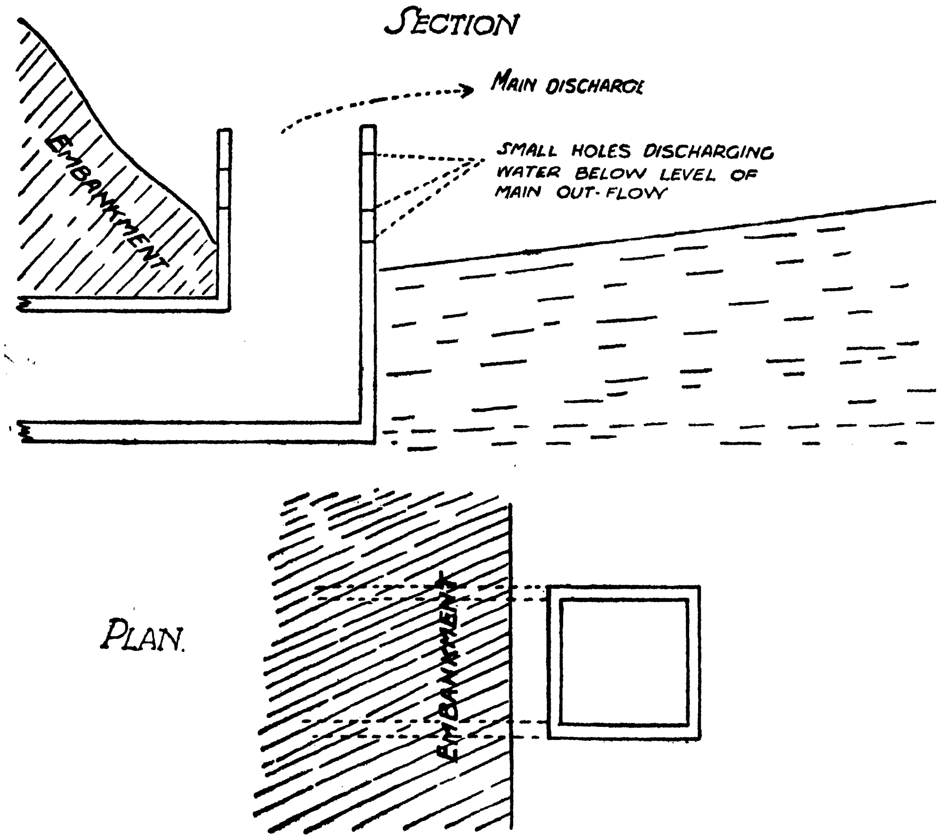

Diagram II.

purpose, by allowing water to percolate. A perforated masonry weir is sometimes erected. But sooner or later the cultivator comes to grief, because he has no calculations to tell him how strong to make his bank, or to give him the right dimensions and design of his weir. If he has been fortunate enough to make his bank strong enough in the first place, he has no calculations to tell him how far he can raise the level of his weir as silt accumulates, without endangering the bank.

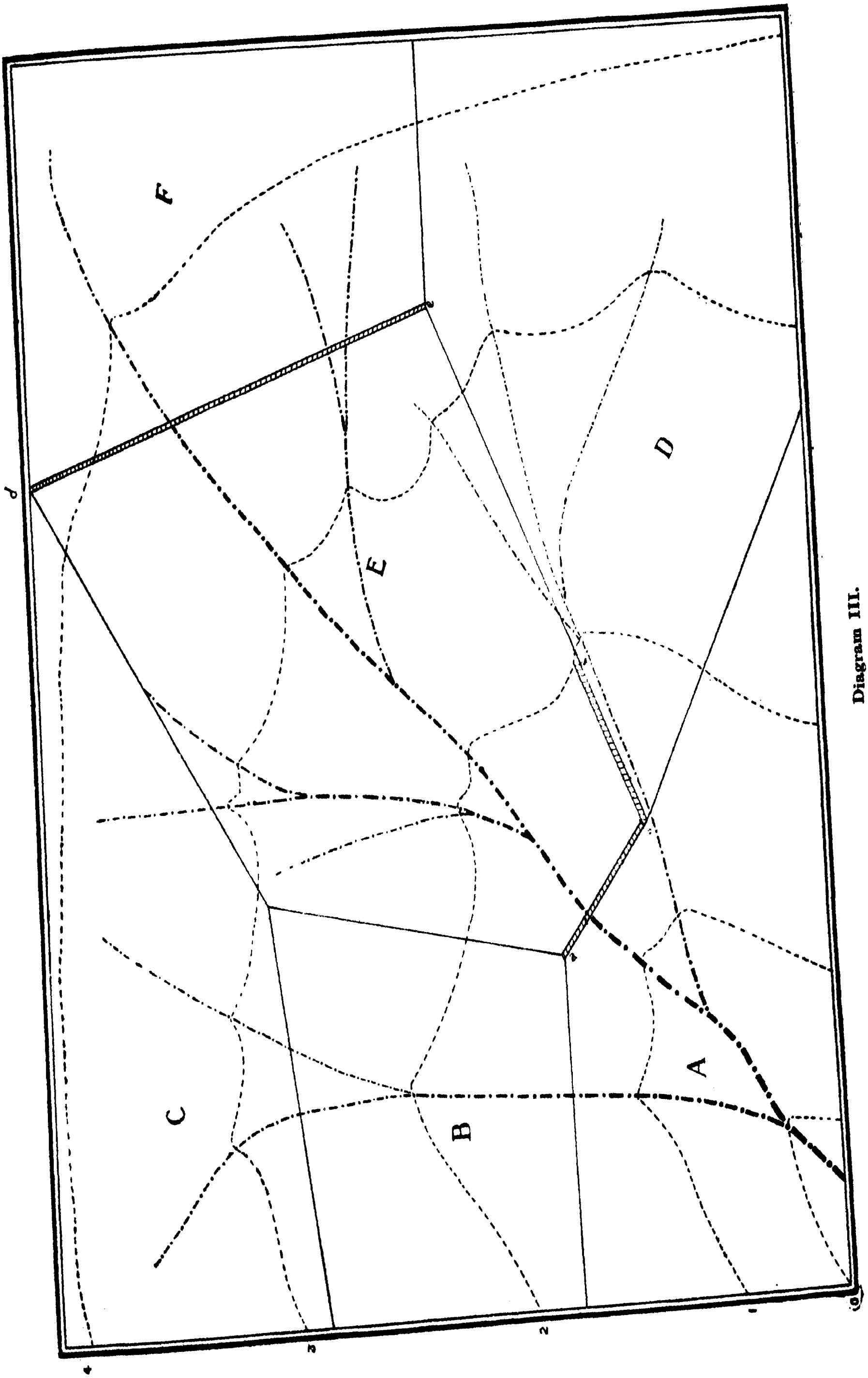

Diagram III.

In short, the problem is one for an engineer, and no man is wise in putting in money into a scheme for improvement on these lines without designs and without an estimate of strength, of cost, and of the cumulative effect by annual stages of water and silt distribution. Many cases occur where the area reclaimed is so small that it is probable that the project has been heavily overcapitalised.

A more general view of the problem is shown in Diagram III.

The owner of field A might put up an embankment similar to that described above. The owners of fields E and F might put up embankments a, b, c, and d, e, both quite probably without waste weirs. They would put them along the boundaries of their fields. Their effect, if they did not breach, would be to prevent soil being washed into a lower field but to accumulate washed soil on a comparatively small area. The diagram also illustrates another point of view from which the problem has to be examined—the limitations to a method of solution, placed by the fact that one practicable project may effect several owners. Again, from the point of view of general rise in the productive standard of land, the individual's boundary embankment offers a very serious objection. Where this embankment is conceived on a fairly large scale and concentrates the surface drainage to flow over a single weir, the land below often suffers more than it did prior to the erection of the embankment. The scheme itself may fail if a land-owner at a higher level develops a similar scheme ; it will almost certainly do so if the original plan aimed at the cure of an advanced stage of denudation, by collecting silt washed off other men's land.

Specification of catchment areas and of gradients has been purposely omitted from the sketches, because the limits for practical solution, taking into account these and other variables, have yet to be worked out.

Finally, the sketches illustrate that a necessary consequence of any successful scheme of field enbankments is the gradual levelling of the land.

From the above discussion a few propositions are derived, some of which are self-evident. Others will require proof by calculation or experiment :--

No. 1. That efficiency of field embankments or a system of embankments depends on—

(*a*) a maximum rate of levelling;

(*b*) a maximum distribution of water;

(*c*) a maximum distribution of silt.

No. 2. That these maxima are limited by nature by —

(*a*) amount and periods of rainfall;

(*b*) catchment area and fall ;

(*c*) the degree to which erosion has already progressed.

No. 3. That the efficiency of a bank depends on—

(*a*) material available for building ;

(*b*) even distribution of water pressure ;

(*c*) design of waste weir and sluice.

No. 4. That the efficiency of field embankments or a system of field embankments depends on a minimum of interference with cultural operations—

(*a*) from the point of view of direct obstruction ;

(*b*) from the point of view of land being under water at sowing time ;

(*c*) from the point of view of reducing the cultivable area as little as possible.

No. 5. That the majority of these ideals of efficiency can be approached more nearly than by existing systems by—

(*a*) embankments along contours ;

or

(*b*) embankments along a straight line which is the nearest practicable approach to a contour.

Dharwar farm.

Mean of 20 years' rainfall, 27 inches.

Month	Fortnight	Inches	Cents	Remarks
April ..	I	0	54	
	II	0	87	
May ..	I	0	58	
	II	1	43	
June ..	I	2	39	
	II	1	48	
July ..	I	1	85	
	II	3	69	
August ..	I	2	46	
	II	1	65	
September ..	I	0	79	
	II	2	88	
October ..	I	2	11	
	II	1	75	
November ..	I	1	7	
	II	0	46	
December ..	I	0	51	
	II	0	15	
January ..	I	0	6	
	II	0	3	
February .	I	0	2	
	II	0	0	
March ..	I	0	1	
	II	0	20	
		27	0	

Diagram IV is a map of the only experimental evidence available in the Southern Maratha Country and this experiment

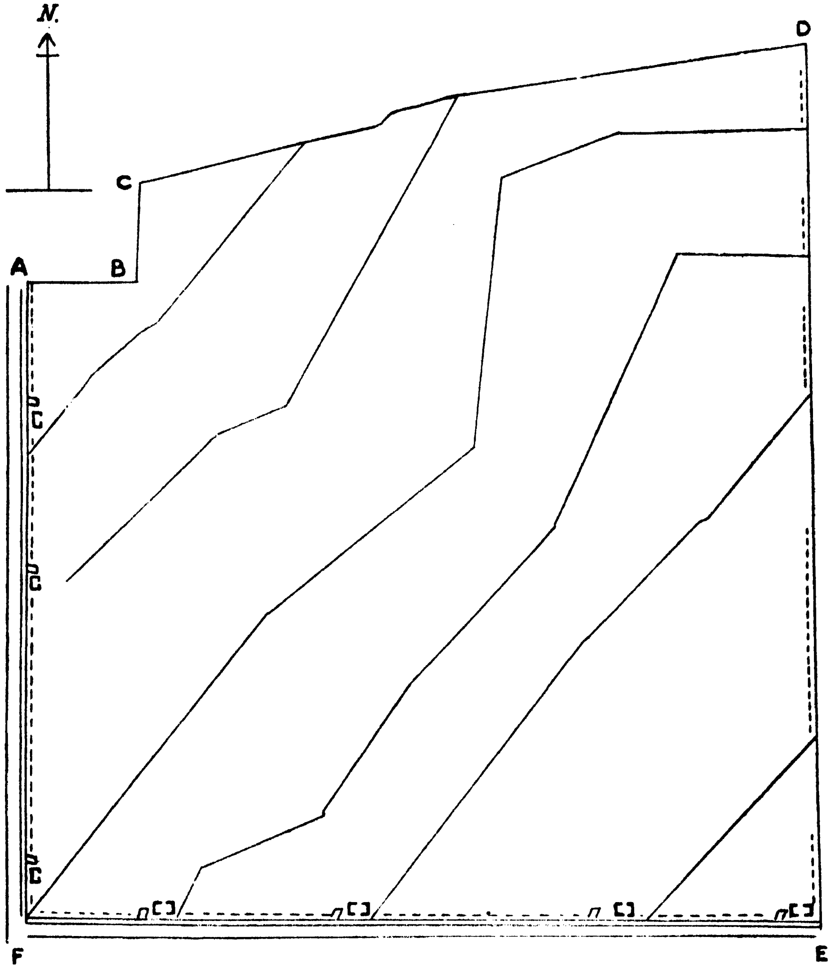

Diagram IV.

Map of "bands" on contour lines on Dharwar farm.
Area A B C D E F definitely limited, 7 acres 13 gunthas.
Catchment area, A B C D E F only.
Boundary CD protected by a road which has become a drainage channel above it.
Soil, black cotton. Fall, about 1 in 60.

Specifications.

From Bench mark E, mark out contour lines at 2 ft. vertical intervals.

Construct a bank 10 ft. wide at base and 2 ft. high along each of these contour lines. Material for bank, black soil. Obtained by ploughing the field and then scraping uphill from the upper half of an area defined by two contours.

At points where contour lines meet field boundaries, carry embankments uphill along the boundary, maintaining the height of 2 ft. above the original base level.

Build waste weirs of stones fitted without mortar at points marked [ ]. Base level of weir 6 in. above base of bank.

Waste weirs to discharge into drains along AF and FE, which must lead the water to a natural drainage channel.

covers only one of the many phases. It serves to illustrate principles only, and specifications given are not offered as a final solution of even this one specified phase. Their basis was conjecture and the results of the experiment, apart from a demonstration of principle, can only yield an empirical basis for further experiment. The table on p. 490 shows the rainfall at Dharwar farm.

The ordinary method of attacking this problem would have been to erect embankments along FE and along parts of DE and AF. The material for these embankments would have been dug from a narrow strip along their upper side. A weir would possibly have been constructed near E.

It is evident, without reiterating discussion, that this method will be very local in effect, unless conceived on a very large scale: that before the whole field can be reduced to one level, water will have to be discharged several feet above the present level of E, and that such an ambitious scheme would involve the diversion of the barrier CD to admit water and silt from outside: that in any case efficiency from the points of view of propositions No. 1 a, b, and c, No. 3 a and b, and No. 4 b is very defective. It is efficient from the one standpoint, proposition No. 4 a.

A series of contour embankments is offered as an alternative to a single marginal embankment. There are the further alternatives of a series in straight lines approximating contours, and of a series parallel to the margin of a field.

Consider any single contour bank represented in Diagram IV. It distributes water, but does not retain it, unless its two ends are diverted towards the higher level. It then complies with the standard of efficiency, that water pressure is distributed evenly along it, except only at its two ends where it departs from the contour line. The cumulative levelling effect of water flow has one dimension less to cope with than has water controlled by a straight bank. The truth of this statement is qualified by the proportion of the bank which must depart from the contour, and by the degree of uniformity of slope of the area on which the levelling effect is operative.

Perhaps this is best illustrated by assuming a perfectly conical hill (Diagram V) of uniform texture and subject to uniform precipitation of water. The immediate effect of a bank along contour 3 would be to accumulate water uniformly along its whole length, and the cumulative effect resulting from deposit of silt, a cone with base line 3 superimposed upon a cone section. The

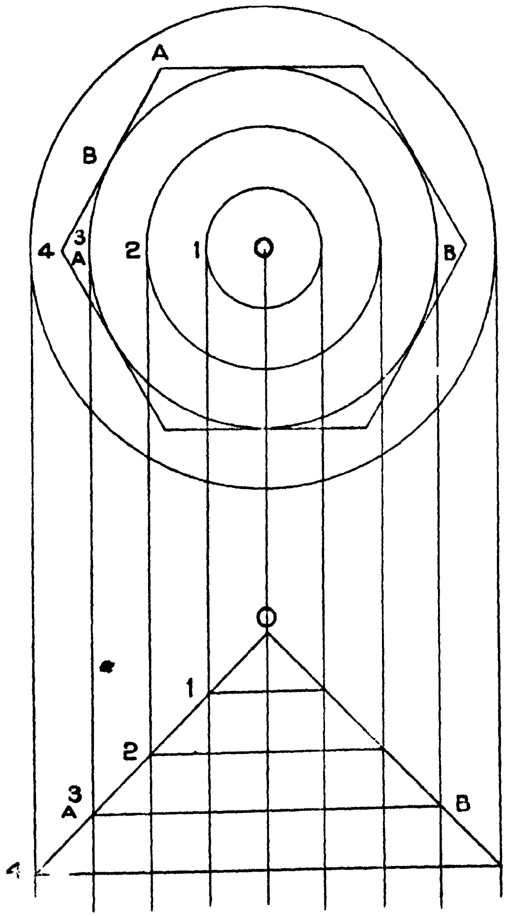

Diagram V.

immediate effect of placing banks at a tangent to the contour—*vide* hexagon described about contour 3—would be to distribute water at uneven depths, and the cumulative effect to deposit silt at unequal depths. In other words, energy would be wasted and consequently result delayed by distorting the original form of contour. An irregular polygon, that is one whose sides are not

tangent to a circle described about O, means a still greater distortion of contour form.

It is again obvious that if bank 3 be breached at any point, any water accumulated along it will be immediately drained off. In practice a bank along the whole of a contour circuit would probably never be realized, in fact usually it will be a very small sector of that circuit. Therefore the bank placed along a contour in practice is not a bank capable of effecting any storage. If storage is effected by continuing the bank at the two ends uphill, it is obvious that the water can be drained off completely by breaching the bank at any point, except where it is diverted from the contour. The expression " contour bank " used hereafter will imply departure from contour at the ends.

Multiplications of banks in series must be worked out with reference to each phase. Diagram VI depicts a slope AC with

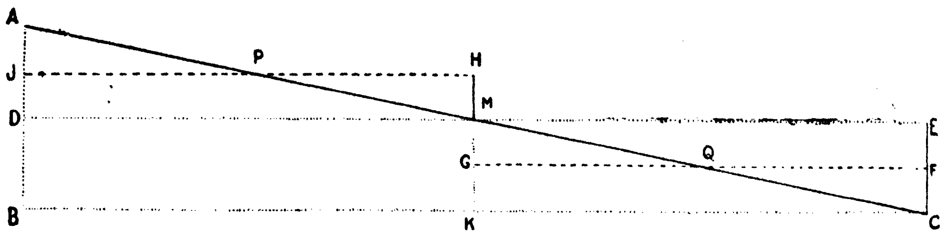

Diagram VI.

horizontal base BC. A bank raised at C would ultimately produce a new surface level DE. Two banks, one at C and one at M (AM = MC), would produce two new surface levels JH and GF, and since the area of the triangle A J P is $\frac{1}{4}$ of that of the triangle ADM, the total movement by a natural agency involved to secure two new levels is $\frac{1}{2}$ of that required to secure one new level. Similarly, by subdivision of the slope by banks so that AP = PM = MQ = QC the total movement involved can be shown to be $\frac{1}{4}$ of that required to produce one new level[1]. In other words, the amount of work expected of natural agency to reduce a uniform slope to one or more levels and consequently the time involved in completing this work, given that natural agency is sufficient, varies inversely with the number of equidistant banks.

[1] Henderson. *Bombay Agri. Dept. Bull. No.* 64, p. 15.

This establishes for a uniform slope a simple ratio between vertical height, horizontal or surface distances between banks, and amount of soil to be moved, to secure a horizontal surface level between two banks, but no such simple ratio holds for a non-uniform slope. Is it possible to deduce a general expression which will give as a function of vertical or horizontal distances the correct intervals between banks, so that there is an equal amount of levelling by natural agency required in each interval ?

A series of contour banks naturally possesses the advantages already enumerated for single banks, over a series of straight banks, and in addition possesses the very great advantage that the field need not be broken up by drains. Even if it is possible to build the main discharge from a straight bank at field margin, there must always be a sluice at the place where water stands deepest. Contour banks can make use of one original drainage channel, or divert water to a new channel, without breaking up a field by new drains as well as banks.

Contour banks obviously do not satisfy the condition of minimum interference with cultivation, unless they can be built so broad, compared with their height, that cultivation can be done across them, and crops grown on them. It has been found practicable to harrow and drill across the banks in the experimental case quoted. Ploughing has yet to be tried. The necessary height of banks becomes less, the closer they are placed. If the other variable factors preclude a similar design of section to that specified for the above described experiment, there is still the alternative of straight banks lying as nearly as possible on contour lines, and the practicability of applying this alternative will depend on the frequency and depth of undulations along the line of the bank, or, in other words, the degree of approximation to the contour. The weight which must be given to this objection of interference with cultivation in straight lines will vary under different conditions of farm economy, but is generally heavy in the black soil country, where large areas per pair of bullocks are the rule, and it will increase if only because the iron plough is spreading so rapidly.

THE PLANT *CARICA PAPAYA* AND ITS ENZYME.*

BY

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Assistant to the Imperial Agricultural Chemist.

Commercial aspect.

In spite of the general usefulness of its fruit and especially of the extraordinary property of its milky juice, the plant *Carica Papaya* has received but little attention as yet either of the agriculturist or the scientist in India.

From an examination of the details obtainable of the papaya cultivation in America, the Philippines and Ceylon, it seems that it should prove to be a profitable concern in India, specially if the papain industry and the various commercial products therefrom are systematically developed.

The following information regarding the trade of Ceylon in this economic product will show what possibilities there are for India.

The export of papain from Ceylon is in the hands of a few firms who buy from the villages in the interior and pay from about Rs. 5 to Rs. 7 per lb. The purified commercial papain fetches about 12 *s.* (Rs. 9) per lb. in the European markets. The following is the statement[1] from the Principal Collector of Customs from Ceylon during the three years 1911, 1912, and 1913. This gives an idea of the local output and the destinations.

* Paper read at the Eighth Indian Science Congress, Calcutta, 1921.
[1] *Tropical Agriculturist*, Vol. XLII, p. 167.

Countries to which exported	1911		1912		1913	
	Quantity	Value	Quantity	Value	Quantity	Value
	lb.	Rs.	lb.	Rs.	lb.	Rs.
United Kingdom	4,054	20,320	9,088	34,332	12,705	44,185
FOREIGN COUNTRIES						
Belgium	..	..	76	229	376	1,881
Germany	2,007	11,401	1,708	7,159	2,555	12,705
U. S. A.	550	2,500	2,048	8,948	2,912	13,078
TOTAL	6,611	34,221	12,920	50,668	18,548	71,849

The United States of America is the largest consumer, importing annually, it is estimated, to the value of £15,000 to £16,000. The price in the United States for papain varies from 7*s*. 6*d*. to 15*s*. per lb. according to the quality as tested to determine its digestive properties.

The following extract from the Agricultural Report of Montserrat, 1917-18, will show the condition of the industry there in more recent times :—

"The actual exports of papain in 1917 totalled 1,877 lb., in value £1,173, compared with 2,476 lb. valued at £1,560 exported in the previous year. The falling off in production is attributed to the neglect of the cultivation of papaya amongst the planters, as a result of the greater attraction of cotton. With sufficient inducement there might be very considerable development in the interesting industry."

In 1917, the Agricultural Society of Ceylon was in receipt of a communication from Messrs. Carter, Cummings and Co., Toronto, Canada, manufacturers and importers of pharmaceutical products, intimating that they were very large buyers of dried papaya juice. These correspondents were desirous of obtaining supplies of pure unadulterated dried papaya juice and desired that anyone interested should communicate to them or to the Secretary, Ceylon Agricultural Society.

From the above statement it appears that at present the demand for unadulterated papain is more than the supply.

From an outline given below of the selling price and also the cost of the production of papain, it will be seen that papain industry in India would be quite lucrative :—

Number of trees per acre	MINIMUM 400 trees (Bombay Presidency)	MAXIMUM 500 trees (540 grown in America)
	lb.	lb.
Papain @ ½ lb. per tree (in Ceylon the yield of papain being ½ to ¾ lb. per tree)	200	250
	Rs.	Rs.
Selling price of papain @ Rs. 5—6 per lb.	1,000	1,500
Deducting the cost of cultivation, collection and preparation of papain, etc.	200	250
Profit from papain	800	1,250
Profit from fruit left after extraction	200	250
Net profit	1,000	1,500

The present supply of papain comes almost entirely from Ceylon and the West Indies, more especially from the island of Montserrat.

Commercial papain is often adulterated with arrowroot, starch, rice conjee or flour. Activity number, *i.e.*, the quantity of protein digested by unit weight of papain in a fixed time and at a particular temperature, has been found to vary much in the commercial samples. As estimated by the method of D. S. Pratt[1] on milk protein, commercial specimens from Ceylon gave the following numbers : 0·1, 5·6, 9·7. A Mexico sample gave 12·9, while a West Indies sample gave 40·0. Prepared in the Philippine laboratory, fresh latex (on dry basis) gave 45·8, undried latex (on dry basis) gave 45·4, alcohol-precipitated papain gave 72·2, and Pusa prepared pure sample gave 44·4 on egg albumin (with milk protein probably this will give a much higher figure).

[1] Papain. *Phil. Jour. Sci.* (1915), **10**, pp. 1—33.

AGRICULTURAL ASPECT.

Historical[1]. De Candolle believes the plant to be a native of the Gulf of Mexico and of the West Indies and doubtfully of Brazil. The non-Asiatic origin of the papaya is proved by its having no Sanskrit name ; the modern Indian name being evidently derived from the American word *papaya,* itself a corruption of Carib *ababai.* Ainslie says it is a native of both Indies, an opinion held by many popular writers, but not supported by the botanists. Atkinson regards it as introduced into India by the Portuguese. It is pointed out by Brandis that its name *thimbawthi* means fruit brought by sea-going vessels.

In 1626, seeds were sent from India to Naples. The tree must therefore have been introduced into India at an earlier date or just after the discovery of America.

Uses of papaya. The following interesting account of the numerous uses of the papaya, chiefly by the natives of Central and South America, is taken from an article by F. B. Kilmer which appeared in "The American Journal of Pharmacy."[2]

" Quite universal is the knowledge of the unique property that has given to the papaya its world-wide fame, *viz.*, the power of its milky juice to soften and dissolve tough meat. The native uses of the papaya are numerous and varied. The bark is used in the manufacture of ropes ; the fruit is edible and, according to the local conditions, may be sweet, refreshing and agreeable, or in other localities it is sickly sweet and insipid. The fruit finds a large consumption among the natives and is considered to be nutritious.

"The ripe fruits are eaten as melons and excellent preserves are made of them by boiling them with sugar (like citron).

" Green fruit is made into plain and spiced pickles which are highly esteemed.

" The seeds are reported as anthelmintic and emmenagogue; they are also used as a thirst quencher, and form component part of a drink used in fevers and also used as a carminative.

1 Watt, G. *Dict. Eco. Pro. India*, Vol. II, p. 159.
2 *Jamaica Dept. Agri. Bull.*, August 1903.

" Syrups, wines, elixirs made from ripe fruit are expectorant, sedative and tonic.

" Pimples are cleaned by the milk of the ripe fruit. By its power of dissolving stains papaya has acquired the name melon bleach. The leaves or a portion of the fruit are steeped in water and the treated water is used in washing coloured clothing, especially black ; the colours are cleaned up and held fast.

" The seeds are eaten as a delicacy. The strange and beautiful races of the Antilles astonish the eyes of the travellers who see them for the first time. If they are to be believed, their clear, clean complexions and exquisite pulp-like flesh arise from the use of the papaya fruit as a cosmetic. A slice of the ripe fruit is rubbed over the skin and is said to dissolve spare flesh and remove every blemish."

The medicinal properties of papaya are numerous and well-known to the Indians[1]. Most of these properties are due to the presence of papain in the juice. The separation of papain was regarded as a commercial secret.

Cultivation. Carica Papaya is a tropical plant, and outside the tropics it is grown as an ornamental tree that only occasionally bears fruit. In Hawaii[2], it thrives best below 1,200 feet altitude producing the best fruit in the warmest locality. Cold retards the growth of the fruit and its ripening. The plant once established is capable of enduring a wide range of moisture variations in the soil, but under water-logged conditions the plant suffers. It can be grown in various types of soil if proper drainage and aeration conditions are maintained. The papaya is usually propagated by seeds. Recently, however, a sexual propagation, such as grafting, has been tried in America[3] and also in India[4] (Lucknow) with some success. It has been claimed that trees so propagated fruit more quickly than

[1] Kirtikar, K. R., and Basu, B. D. *Indian Medicinal Plants*, pp. 574—577. Dymock, W. *Pharmacographica Indica*. Umney, J. C. *Agri. Ledger* (1896), No. 31.

[2] *Hawaii Agri. Expt. Stn. Bull.* 32.

[3] The Grafted Papaya as an Annual Fruit Tree. *U. S Dept. Agri. Bur. Plant Indus. Cir.* 119.

[4] *Dept. Land Rec. and Agri. U. P. of Agra and Oudh Bull.* 37.

seedlings. Transplanting at various stages of the plant is possible without any injury to it.

It is best to plant seeds in well-drained porous soil covering them about half an inch deep. In from two to six weeks the seedlings appear, germination being hastened by heat. In about a month after germination the seedlings are large enough to be transplanted to pots in which they remain for another month before being placed in the orchard where holes four feet deep and four feet wide were dug previously. The distances between trees should be about ten feet in each direction.

The following fertilizer has been successfully tried at the Hawaii Experiment Station on young plants :—

	lb.
Superphosphate	800
Sulphate of potash	315
Nitrate of soda	250
Sulphate of ammonia	190
Black sand (volcanic ash)	445

This has been applied at the rate of 1 pound per tree at planting time. In Bombay Presidency, house, farm or stable refuse 20 cart-loads per acre has been used with success. It is also found that two ploughings and two harrowings just before sowing the seed improved the growth of plants.

The papaya plants bear male, female or both kinds of flowers. Of course, those bearing male flowers do not produce any fruit. As the flowers appear in about five months after planting, the male ones should be picked up leaving only about 10 of these per acre. The plant, if properly manured, will last from five to ten years, but the period of profitable productivity is usually not more than three or four years.

Changing sex[1]. It is remarkable to note in this connection that on many occasions male flowering plants have been found to change their sex. Dr. John T. Gulik has noted an instance of this. A tree one and a half year old had produced only staminate flowers. The top of the tree was cut off, leaves plucked. After some months new branches appeared and these bore fruit.

[1] Iorns, M. J. *Science*, n. s. (1908), No. 708, pp. 125, 126.

Breeding. There are various forms of the fruit. Some are elongated known as the Ceylon variety, some are round, some have short peduncles, while others are on long peduncles. The forms depend mainly upon the distribution of sexes. There are good reasons to believe that by proper breeding it will be possible to produce the most desirable characteristics in the fruit only to hold the variety reasonably stable by the same means as are employed in maintaining the seed varieties of vegetables and garden flowers.

BIOCHEMICAL ASPECT.

Composition. The general composition of the papaya fruit is shown by the following analysis (*Maine Sta. Bull.* 158).

	Per cent.
Water	90·75
Protein	0·80
Fat	0·10
Nitrogen free extract	6·32
Fibre	1·09
Ash	0·94

The total soluble solids in the case of papaya fruit have been found to be low throughout the ripening process and to increase as the fruit ripens[1].

"The insoluble solids are about 3 per cent. in the green fruit and decrease to about 1 per cent. in the ripe fruit. The ash, acid and protein occur in small quantities and are quite constant. The sugars in the green fruit, however, amount to over 2 per cent., but ncrease rapidly as the fruit increases in size and approaches ripeness. The hydrolisable carbohydrates are almost nil, and fat, fibre and undetermined matter occur only in small amounts."

The most important property of the papaya fruit from a biochemical point of view is the proteolytic power possessed by the latex of the fruit.

So universal is the knowledge of this unique property of the milky juice of the unripe fruit that it attracted the notice of the western investigators[2] as early as 1878.

[1] *Expt. Sta. Rec.* 32 (1915).

[2] Herr Witmack of Berlin. *Pharm. Jour.*, 30th Nov., 1878. Dr. Sidney Martin of London *Jour. Physiol.*, **5**, pp. 213—230; also *Jour. Physiol.*, **6**, pp. 336—360. Wurtz. *J. C. S. Abstr.*, **1880**, **58**, p. 750. Watts, F. *Agricultural News*, **1**, 4.

Their researches were mainly directed to a determination of the composition of papain, the nature of the products of activity of papain on proteins, the medium in which papain acts best, and the temperature suitable for its action. The literature on the subject is too extensive to be dealt with here; many of the results which have been reported are not conclusive and some are contradictory.

Experiments carried out at Pusa

Preparation of crude papain.

A one year old healthy plant was selected in the Pusa kitchen garden, and with a specially prepared ebonite knife shallow longitudinal incisions not more than one-eighth of an inch deep were made on unripe well-grown fruits. The juice was collected in a glass beaker. It has been found that fruits having only three or four incisions can be made to bleed on subsequent operations after an interval of a day or two, but those having seven or eight incisions produce little or no latex when incised again. Just after rain the latex was thin and did not coagulate at once (*i.e.*, in 15 to 30 min.) which was however the case with juice collected four or five days after rain. Early morning is the best time to tap.

The juice so collected was immediately filtered through a piece of thin muslin and dried at about 35°C. for two days when it formed a cream-coloured, hard but brittle mass having an unpleasant putrid smell characteristic of the papaya fruit. This was then finely powdered in a mortar and called crude papain. Prepared in the above way, the yield of crude papain was found to be 16–18 per cent. of the juice in the rainy season in Bihar, while that collected by F. Watts at the Antigua Experiment Station, West Indies, was 19·4 per cent.

A sample of papain prepared at Pusa was found to contain—

(1) a globulin,

(2) an albumin,

(3) albumoses (in considerable quantity),

(4) a milk curdling ferment.

The major portion of the protein, therefore, is present in the form of albumoses. This agrees with the results obtained by Martin and Pratt. There could be found no sugar or starch in the juice, neither did it contain any of the common ferments such as amylase, invertase, oxidase or peroxidase. The absence of oxidase and peroxidase in the sample prepared at Pusa may be noted, some workers having expressed the opinion that these enzymes are usually present.

The sample contained :—

	Per cent.
Total organic nitrogen ..	9·60
Albuminoid nitrogen (as found by copper hydrate precipitation method)	2·44
Ammoniacal nitrogen	0·59
Ash	6·92
Lime (CaO)	1·21
Magnesia (MgO)	2·19
Potash (K_2O)	0·69
Soda (Na_2O)	0·60
Phosphoric acid (P_2O_5)	0·96

Purification and standardization of papain.

Having obtained a sufficient quantity of crude papain, it was purified in various ways described below. A pure product may also be obtained directly from fresh latex. Its preparation from latex was carried out as follows :—

Twenty grm. of fresh latex were well stirred with 100 c.c. of 95 per cent. alcohol. A gummy white coagulum was thrown down that was readily collected in a ball. The alcohol was poured off and replaced with 50 c.c. of the same strength. The papain readily crumbled to a fine powder during the second treatment with alcohol. It was filtered, using the pump, and washed twice with ether to remove a semi-solid yellow wax and to facilitate drying. The washed papain was dried *in vacuo*, giving a perfectly white powder with a faint characteristic odour ; the yield of papain obtained was 3 grm. The time required from latex to dry papain was about 30 minutes.

The activity of these various products was determined according to the method recommended by Heyl, Caryl and Staley[1]. The following results were obtained.

[1] Standardisation of Papain. *Amer. Jour. Pharm.* (1914), **86**, pp. 542–550 ; also *Analyst* (1915), pp. 57, 58.

TABLE I.

Determination of proteolytic activity of papain purified in different ways. In each case 15 *c.c. egg albumin were made up to* 25 *c.c. with* 1 *per cent. NaCl and* 1 *c.c. papain solution* (0·01 *grm. papain*) *added. The mixture was digested for* 15 *minutes at* 80°*C.*

No. of flask	Papain used prepared as follows	Medium	Protein unacted	Protein digested	Units of protein digested by one unit wt. of enzyme	Per cent. protein digested in 15 min. at 80° C.
1	Papaya juice dried at 35°C.	Neutral	0·197	0·250	25·0	55·9
2	Above sample extracted with water (10 times) for 6 hrs. and filtered; the extract precipitated with 2 vols. of 91 per cent. alcohol and dried over $CaCl_2$ ..	,,	0·209	0·238	23·8	51·0
3	Fresh latex precipitated with 2½ vols. of 91 per cent. alcohol and dried over $CaCl_2$	,,	0·193	0·254	25·4	56·8
4	Above sample washed with ether after a day's drying and finally dried over $CaCl_2$	,,	0·147	0·300	30·0	67·1
5	Fresh latex precipitated with 5 vols of 94 per cent. alcohol and washed 3 times with ether, dried over $CaCl_2$	,,	0·189	0·258	25·8	57·7
6	Above sample ..	Acid	0·148	0·299	29·9	66·8
7	Same as in 5 and 6 ..	Alkaline	0·354	0·093	9·3	2·8
8	Blank, no enzyme ..	Neutral	0·447	nil	nil	0·0

These figures show that the samples prepared at Pusa compare favourably with the best marketed products from the Philippines, Mexico or Ceylon.

It will appear from what has been stated above that the processes involved in the preparation of both the crude papain or

the most active product are extremely simple, but unless the directions are scrupulously adhered to, the product will be very inferior in quality and consequently will fetch a poor price.

In preparing the crude papain, the following points should be specially observed :—

(1) The juice should be dried as soon as possible.
(2) In drying, the temperature should not rise above 40°C. Both these ends are obtained in some places by drying on hot plates.
(3) The final drying should be done, if possible, *in vacuo*.
(4) Lastly, the product should be ground to powder and at once bottled up using air-tight stopper or packed in lead-lined wooden boxes.

The effect of temperature and reaction of the medium on the rate of action of papain.

A few tests were made to elucidate these points because the available information is somewhat contradictory. The following results were obtained.

TABLE II.

Standardization of crude papain and testing of the digestive activity in different media. (In all cases, digestion was carried out for 15 minutes).

Grm. coagulable protein in 15 c.c. egg albumin solution	c.c. of 1% papain in 1 % NaCl	Temperature of digestion	Quantity of coagulable protein digested	% of protein (coagulable) digested	Nature of medium
0·309	1 c.c.	40°C.	0·0847	27·43	Neutral
0·445	,,	90–95°C.	0·2930	65·84	,,
,,	,,	,,	0·2690	60·45	Acid
,,	,,	,,	0·1655	37·19	Alkaline
0·467	,,	80–88°C.	0·2830	60·60	Neutral
,,	,,	,,	0·2830	60·60	,,
,,	2 c.c.	,,	0·3405	72·93	,,
0·544	1 c.c.	80°C.	0·2620	47·29	,,
,,	,,	,,	0·2450	45·22	,,
0·427	,,	,,	0·2590	60·65	,,
,,	,,	,,	0·2550	59·72	,,

It will be seen that the Pusa sample of papain acted best in neutral and very slightly acid solution. A small quantity of alkali was found to decrease the activity considerably, but it did not totally stop it, as would be the case with pepsin.

The result obtained for digestion at temperatures as high as 80°C., 90°C., 95°C., are so remarkable that comment on them will not be made until the matter is further investigated. It is no doubt owing to this remarkable property that a few pieces of unripe papaya put into almost boiling tough meat soften the latter very quickly.

TESTS OF PUNJAB WHEATS Nos. 11 AND 8A AT LYALLPUR, 1915-16—1919-20.

BY

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THE relative yields of these two wheats have been tested every season since 1915-1916; the number of tests amounts to 170 pairs of plots. Opinions and tests of their value to the miller and baker have been obtained by Mr. Milne, Economic Botanist, Punjab, and also from Mr. Humphries, the well-known Home expert.

They have been sown for thorough tests again this season (1920-21) on 60 pairs of plots, and it is hoped to have further milling and baking tests of this crop. But it seems advisable to summarize results to date, and the results may interest wheat growers in other provinces.

A few words are necessary as to the history of these two wheats. Punjab 11, a bearded wheat with amber-coloured grain and reddish chaff, was one of the twenty-five varieties of wheat separated by Mr. Howard, Imperial Economic Botanist, from a collection of Punjab wheats. Previous to the distribution of any seed by the Agricultural Department, this variety already constituted the bulk of the crop over the greater part of the Lower Chenab Colony. Preliminary tests soon showed it to be a heavier yielder than most of the other twenty-four varieties, and further tests showed it to be better than any of them. One variety, No. 17, obtains a small premium over No. 11 in the market for superior quality of grain; but continued tests showed it to yield distinctly less than No. 11. Another variety, No. 9, may possibly rival No. 11 as to yield under very favourable conditions as to soil and water, but it failed when compared with No. 11 on lighter soils with less irrigation. No. 11

also yielded better than Pusa 12 in practically every one of a long series of experiments at Lyallpur, under greatly varied conditions of soil and irrigation.

The variety No. 8A is one of a large number found by Mr. Milne, more or less as strays, in various fields inspected in the course of systematic and detailed surveys of the wheat fields of the province. Botanically the characteristics of its ears are very similar to those of No. 11. The most useful characteristic for distinguishing the two varieties is the velvety hairiness of the glumes of 8A. Of these new selections, 8A is apparently the only one yielding nearly as well as No. 11. All these selections have been grown and studied by Mr. Milne: and, out of some half dozen handed to the Agricultural Section at Lyallpur for trial, 8A has been proved to be much the heaviest yielder. Another new selection, No. 8B, appears, from the tests quoted later, to be a wheat of highly superior quality; but continued tests showed it to be distinctly inferior in point of yield at Lyallpur to No. 11. It might prove a very useful wheat elsewhere.

As extracted from the annual reports the results appear as in Table I (p. 515). The standard deviation (root-mean-square of departure from average) of the differences have been worked out in each case where the number of pairs of plots is sufficient for the determination to be of any value. From this the standard error of the average difference has been calculated by dividing the standard deviation of the differences between pairs of plots by the square root of the number of pairs of plots in each series. According to ordinary statistical methods this would be the best way of judging of the reliability of the results. The standard errors thus calculated are given in column 12.

On examining the results it will be seen that they include statistically significant* differences in favour of both varieties.

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* If the frequency of the errors is "normal" then an error, equal to 0 6745 × standard error, will occur in one direction or the other in approximately half the experiments. A difference less than two-thirds of the standard error must therefore certainly be regarded as insignificant. On the other hand, under these conditions, the chances are 24 : 1 against an error occurring in one direction, greater than 1·75 × s.e. A difference as great as this may therefore be regarded as certainly significant.

The most reliable results are those under farm cultivation. If only the significant differences in these are studied and compared with the average crop, it will be seen that in the case of poor crops, or of comparatively unfavourable conditions, *e.g.*, experiments 1–4, the differences are in favour of No. 8A : whereas under favourable conditions, as in experiments 8–10, where good crops of both varieties were obtained, the differences are in favour of No. 11.

Moreover, the relative degrees of difference are consistent with this theory : the greatest differences in favour of 8A are in the poorest crops, and the greatest differences in favour of No. 11 are in the case of the best crops.

The results of the experiments on the tenants' area, though perhaps not entirely inconsistent with this theory, do not confirm it so well as might be expected at first sight. But if the original data (given in annual reports) be consulted, it will be observed that the total crop in the individual experiments varies very considerably. For instance, series No. 18 (Table I) includes yields of over 30 maunds per acre. No. 20 includes yields of over 29 maunds per acre, and Nos. 16 and 17 include fields which yielded 20 maunds per acre. If the theory suggested be true, the averages of such series can hardly be expected to prove very consistent.

The experiments on the tenants' area in each year have therefore been re-arranged by grouping together all those fields in which the yield of No. 11 was within the following limits :—

(1) Under 16 maunds per acre.

(2) 16 maunds per acre to 22 maunds per acre.

(3) 22 ,, ,, ,, ,, 28 ,, ,, ,,

(4) Over 28 maunds per acre.

At the same time, an attempt has been made to deal with the results in the best way possible, in the light of the study of these experiments which has been carried on during the last few years (with Mr. Jacob's assistance). In the first place the result given is, wherever possible, the average difference between one plot and the mean yield of the two adjacent plots. In the second place,

the standard error of the comparison of two plots (or one plot with two adjacent plots), given in column 10, is not the standard deviation of these differences in the particular series, as in Table I. Instead, a round figure is used, which is estimated from the root-mean square of the differences between plots of the same shape and size when both grow the same variety. As this method in general gives higher value for the standard error, and as the estimates for the errors have been liberal, the estimates of the probability of the significance of the results are very conservative, as compared to those arrived at by the ordinary method.

For instance, the figure for standard error of the average difference in experiment No. 5 in Table I is 0·59 maunds per acre, whereas the figure used in Table II (p. 516) for the same series (No. 3 in this Table) is 1·12 maunds per acre. Finally, the mean differences, in the groups of series of experiments in Table II, are given in Table III (p. 518).

Examining Tables II and III, we see that where the yield per acre is under 16 maunds, the results are all in favour of No. 8A. The average difference is $1\frac{1}{2}$ maunds per acre. When the yield is between 16 and 28 maunds per acre, the result may be in favour of either variety. Most of the differences are insignificant in comparison with the standard error; but some are certainly significant, so that it appears that, in the case of such crops, the result of growing 8A instead of No. 11 cannot be predicted. The average difference on all the experiments between these limits is negligible. Where the yield per acre is over 28 maunds the results are in favour of No. 11, and there is a highly significant mean difference of 1·3 maunds.

To sum up, the effect of growing No. 8A instead of No. 11 is variable. But as this effect is determined by some of the conditions which determine the yield per acre, there is some relation between yield per acre and the result of experiments in which the varieties are compared. When the crop is worse than 16 maunds per acre, 8A does better; when it is between 16 and 28 maunds, either may do better in any particular field, the yields from the two varieties being about equal when the results from a variety of fields yielding

this amount are averaged. With sufficient water, early sowing, well tilled land and a good season, No. 11 may yield as much as $1\frac{1}{2}$ or 2 maunds per acre more than 8A.

The two wheats being so similar in yield, it is necessary to consider very carefully any difference that there may be in the quality of the grain of the two varieties.

For comparing the quality of these two wheats we have at present the results of three distinct series of milling and baking tests:—A series of tests made by Humphries on the samples of the 1916-17 crop;* series of tests carried out by Mr. Milne,† in conjunction with various experts in this country, on the crop of 1918-19; and a second series of tests by Mr. Humphries also on the crop of 1918-19.* For the latter series, the wheats were grown in alternating strips in the same field, each repeated several times. The samples of each variety were labelled simply "A," "B," "C," "D," "E," the key to the lettering being retained at Lyallpur. Five wheats were included in all these series:—

Punjab variety No. 8A, Pusa 12, and Punjab varieties 17, 11 and 8B.

Only the shortest possible summary is here needed as to the results of these tests and judgments:—

As judged by appearance:—

1916-17 crop. Mr. Humphries judged Punjab 8B first, Pusa 12 second, remainder about the same.

1918-19 crop. Mr. Humphries would have priced them all practically the same: he would, if he were unable to use any other method, if buying for ordinary bread-making purposes, have preferred Pb. 17, and for the making of biscuit or pudding flours Pusa 12.

Two experts who judged for Mr. Milne placed the wheats in the following order of merit:—

Pb. 8A, Pb. 8B, Pb. 17, Pb. 11, Pusa 12;

and a third expert in the order:—

Pb. 8B, Pb. 17, Pb. 8A, Pb. 11, Pusa 12.

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* Results not yet published.

† Results reported in the *Ann. Rept. Punjab Agri. Dept.*, 1918-19, Pt. II.

RESULTS OF MILLING AND BAKING TESTS.

1916-17 crop. Taking everything into consideration, Mr Humphries found Pb. 8B and Pusa 12 very good, 8A poor, remainder medium.

1918-19 crop. As to their behaviour in the mill Mr. Humphries places them in the order :—

Pb. 8B, Pb. 17, Pb. 8A, Pb. 11, Pusa 12.

After the baking tests, taking everything into consideration, he placed them in the order :—

Pb. 8B, Pb. 17, Pb. 11, Pusa 12, Pb. 8A.

He regards Pb. 8B as of outstanding merit, and worth two shillings more per quarter than Pb. 8A.

On practically all considerations affecting the miller, Mr. Milne's tests place Pb. 8A and Pb. 8B at the head of the list, followed by Pb. 17, Pb. 11 and Pusa 12 in the order given.

Mr. Milne does not appear to regard his baking tests as very reliable. As to size of loaf his " order of merit " is distinctly different to Mr. Humphries. The latter found all to behave as strong wheats, comparing well with " London Households ;" but he found them to differ little from each other ; so that it is not remarkable that Mr. Milne's order does not agree exactly with that of Mr. Humphries.

As to colour of loaf and crumb, Mr. Milne places the wheats in the order :—

Pb. 8B, Pb. 8A, Pb. 17, Pb. 11, Pusa 12 ;

and Mr. Humphries in the order :—

Pb. 8B, Pb. 11, Pb. 17, Pusa 12, Pb. 8A.

He, however, makes little difference between the last four.

To convert these differences in quality into annas per maund we have only Mr. Humphries' statement, that after making these tests and assuming that a large bulk could be obtained similar to the sample, he would give two shillings per quarter more for No. 8B than for No. 8A. Mr. Humphries regards Pb. 11, taking everything into consideration, as better than No. 8A, so far as the tests have gone yet.

But evidently the difference is only a matter of a few pence per quarter, equivalent to perhaps an anna per maund. On the whole, all we can judge from the tests as far as they have gone yet, is that there would be no great difference in the quality of the grain of the two varieties; and from the figures of the tests of yield it is evident that whatever be the final decision, the introduction of 8A instead of No. 11 will not greatly affect the total production of the colonies.

It is evident that, in the wheats Pb. 11 and Pb. 8A, we have varieties remarkably well suited to local conditions. It is evident that it will not be easy to find a wheat which will be a marked advance on these two. It is probable that in regard to wheat we have nearly reached the limit of advancement by selection. Experience with the Pusa and other imported wheats suggests that it would be a very lucky chance which gave us any imported variety superior, in the local conditions, to our local wheats. For further improvement we shall probably have to look to cross-breeding with Punjab wheats.

TABLE I.

Results of tests of Punjab wheats No. 11 and No. 8A, as extracted from Annual Reports. Standard errors calculated from standard deviation of differences between adjacent plots.

1	2	3	4	5	6	7	8	9	10	11	12	13
No.	Year	Field	Previous crop	Date of sowing	Number of irrigations	Number of pairs of plots	Area of each plot	Average yield per acre of No. 11	Average yield per acre of No. 8A	Mean difference (+) in favour of No. 11 or (—) in favour of No. 8A	Standard errors of mean diffe ence	REMARKS
							Acre	Mds.	Mds.	Mds.	Mds.	Mds.
1	1916–17	Square 26	Wheat	Oct. 28	4	2	$\frac{1}{4}$	21·46	21·77	— 0·31	..	Farm cultivation
2	1916–17	Do.	Cotton	Do.	3	2	$\frac{1}{4}$	21·57	26·15	— 1·58	..	Ditto
3	1917–18	Do.	Wheat	Nov. 9	3	2	$\frac{1}{4}$	14·66	16·42	— 1·76	..	Ditto
4	1917–18	Do.	Cotton	Nov. 10	3	2	$\frac{1}{4}$	23·65	23·70	— 0·05	..	Ditto
5	1917–18	New area	Barley	Nov. 24	3	6	$\frac{1}{2}$	11·55	15·82	— 4·27	0·59	Ditto
6	1918–19	Square 26	Wheat	Oct. 31	3	2	$\frac{1}{4}$	18·45	18·82	— 0·37	..	Ditto
7	1918–19	Do.	Cotton	Oct. 30	3	2	$\frac{1}{4}$	25·19	27·29	— 2·10	..	Ditto
8	1918–19	New area	Wheat	Nov. 11	3	18	$\frac{1}{6}$	25·95	24·32	+ 1·63	0·58	Ditto
9	1919–20	Square 26	Wheat	Dec. 7	3	6	$\frac{1}{4}$	21·54	21·00	+ 0·54	..	Ditto
10	1919–20	Do.	Cotton	Nov. 1	3	6	$\frac{1}{4}$	36·23	34 15	+ 2·08	..	Ditto
11	1919–20	New area	Cotton	Dec. 5	2	9	$\frac{1}{6}$	24·03	25·15	— 1·12	0·44	Ditto
12	1919–20	Do.	Cotton	Dec. 5	3	9	$\frac{1}{6}$	24·17	23·98	+ 0·19	0·40	Ditto
13	1919–20	Do.	Wheat	Nov. 1	2	8	$\frac{1}{6}$	30·30	29·71	+ 0·59	0·30	Ditto
14	1919–20	Do.	Wheat	Nov. 1	3	8	$\frac{1}{6}$	32·06	30·48	+ 1·58	0·66	Ditto
15	1915–16	..	..	..		2	$\frac{1}{2}$	16·10	16·77	— 0·67	..	Tenants' cultivation
16	1916–17	..	..	..	3	7	$\frac{1}{2}$	14·95	15·57	— 0·62	..	Ditto
17	1917–18	..	..	..	3	7	$\frac{1}{2}$	12·55	12·62	— 0·07	..	Ditto
18	1918–19	..	..	..	3	18	$\frac{1}{4}$	20·51	19·43	— 1·08	0·62	Ditto
19	1919–20	..	..	..	2	6	$\frac{1}{4}$	23·28	21·98	+ 1·30	1·06	Tenants' light land
20	1919–20	..	..	..	3	6	$\frac{1}{4}$	20·07	19·64	+ 0·43	1·16	Ditto
21	1919–20	..	..	..	2	6	$\frac{1}{4}$	20·24	21·86	— 1·62	0·73	Ditto
22	1919–20	..	..	..	3	6	$\frac{1}{4}$	23·70	22·29	+ 1·41	1·73	Ditto
23	1919–20	..	..	..	2	8	$\frac{1}{4}$	25·31	25·13	+ 0·18	0·84	Tenants' fair land
24	1919–20	..	..	..	3	8	$\frac{1}{4}$	24·92	24·59	+ 0·33	1·41	Ditto
25	1919–20	..	..	..	2	8	$\frac{1}{4}$	28·45	27·57	+ 0·88	1·27	Ditto
26	1919–20	..	..	..	3	8	$\frac{1}{4}$	34·76	35·11	— 0·35	1·27	Ditto

TABLE II.

Tests of Punjab No. 11 and No. 8A, the results from each area and year regrouped, where necessary, to form series which are more uniform in respect of yield per acre, of the standard variety (No. 11). Standard errors calculated from estimates based on the root mean-square of difference between adjacent or neighbouring plots, where the same variety is grown on both.

1	2	3	4	5	6	7	8	9	10	11	12	13	
No.	Year	Number of plots of each variety	Area of each plot	Number of irrigations	Area where experiment was conducted	Average yield per acre of No. 11	Average yield per acre of No. 8A	Mean difference (+) in favour of No. 11 or (−) in favour of No. 8A	Estimated standard error of a single difference	Estimated standard error of mean difference	$\frac{\text{Column 9}}{\text{Column 11}}$	Probability that mean difference is significant *	REMARKS
					Yields of No. 11 under 16 maunds per acre.								
			Acre			Mds.	Mds.	Mds.	Mds.	Mds.			
1	1916–17	4	½	..	Tenants' area	10·54	12·05	−1·51	3·00	1·50	1·01	0·84*	
2	1917–18	2	¼	..	Square 26	14·66	16·42	−1·66	2·00	1·41	1·17	0·88	
3	1917–18	6	½	..	New area	11·55	15·82	−4·27	2·75	1·12	3·81	0·99993	
4	1917–18	6	½	..	Tenants' area	11·42	11·55	−0·13	3·00	1·22	0·11	..	
5	1918–19	8	¼	..	Do.	13·70	13·85	− ·15	2·75	0·97	0·15	..	Includes fields yielding up to 22 mds.

Yields of No. 11 *between* 16–22 *maunds per acre.*

6	1916–17	3	½	..	Tenants' area	20·79	21·17	−0·38	3·00	1·73	0·22	..	
7	1916–17	2	¼	4	Square 26	21·46	21·77	−0·31	2·00	1·41	0·22	..	
8	1917–18	1	½	..	Tenants' area	19·23	19·29	−0·06	3·00	3·00	0·02	..	
9	1918–19	2	¼	3	Square 26	18·45	18·82	−0·37	2·00	1·41	0·26	..	
10	1919–20	6	¼	3	Do.	21·45	21·00	+0·54	2·00	0·81	0·66	..	
11	1919–20	16	¼	..	Tenants' area	18·77	18·95	+0·71†	2·75	0·69	1·03	0·85	

Yields of No. 11 *between* 22–28 *maunds per acre.*

12	1916–17	2	¼	4	Square 26	24·57	26·15	−1·57	2·00	1·41	1·12	0·87	
13	1917–18	2	¼	3	Do.	23·65	23·70	−0·05	2·00	1·41	0·04	..	*
14	1918–19	2	¼	3	Do.	25·19	27·29	−2·10	2·00	1·41	1·48	0·93	
15	1918–19	18	⅙	3	New area	25·95	24·32	+1·63	2·50	0·59	2·80	0·997	
16	1918–19	10	¼	..	Tenants' area	25·96	23·89	+1·23†	2·75	0·87	1·41	0·92	Includes a few yields of No. 11 over 28 mds. per acre.
17	1919–20	9	⅙	2	New area	24·03	25·15	−1·67†	1·50	0·50	3·34	0·9996	
18	1919–20	9	⅙	3	Do.	24·17	23·98	+0·04†	1·50	0·50	0·08	..	
19	1919–20	20	¼	..	Tenants' area	24·85	24·71	+ ·56†	2·75	0·61	0·91	0·82	

Yields of No. 11 *over* 28 *maunds per acre.*

20	1919–20	6	¼	3	Square 26	36·23	34·15	+2·08	2·00	0·82	2·57	0·995
21	1919–20	8	⅙	2	New area	30·30	29·71	+ ·60†	1·50	0·53	1·14	0·87
22	1919–20	8	⅙	3	Do.	32·06	30·48	+2·24†	1·50	0·53	4·23	1·0
23	1919–20	20	¼	..	Tenants' area	31·70	30·83	+0·36†	2·75	0·61	0·58	..

* In other words a difference as great as, or greater than, 1·51 maunds in favour of 8A may be expected to occur simply due to the unavoidable errors of the experiment, 16 times in 100 repetitions of the experiment under similar conditions. A difference, in favour of No. 11, as great as, or greater than, 1·51 maunds would also occur merely due to error 16 in 100 times. Similarly so great a difference as 4·27 maunds would only occur as a result of errors 7 times in favour of each variety in 100,000 repetitions of Experiment No. 3.

† Mean differences between each plot of 8A and the mean yield of the two adjacent plots of No. 11.

TABLE III.

Mean differences in the groups in Table II and standard errors of these means calculated from standard errors given in Table II.

Fields yielding	Number of series of experiments	Total number of pairs of plots	Mean difference (+) in favour of No. 11 or (−) in favour of No. 8A	Estimated standard error of mean difference	Column 4 / Column 5	Probability that mean difference is statistically significant
Under 16 maunds per acre	5	26	− 1·545	0·563	2·75	0·997
Between 16 maunds per acre and 28 maunds per acre	14	102	− 0·060	0·358	0·01	..
Over 28 maunds per acre	4	42	+ 1·320	0·321	4·10	0·99998

Fig. 1. A sugarcane plant killed by *Striga densiflora* (a) attached to its roots.

Fig. 2. A shoot of *Striga densiflora* (a) attached to the roots of cane.

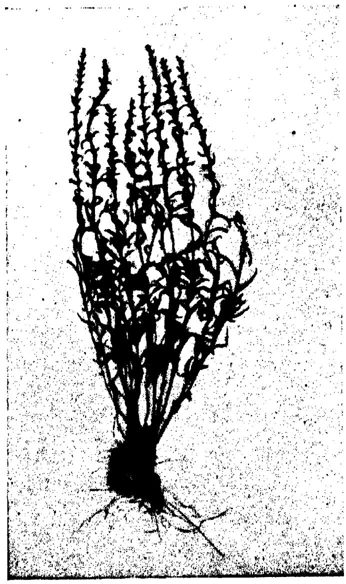

Fig. 3. *Striga densiflora* with a few of its off-shoots.

STRIGA AS A ROOT PARASITE OF SUGARCANE.

BY

JAI CHAND LUTHRA, M.Sc.,

Assistant Professor of Botany, Agricultural College, Lyallpur.

IN September 1920, when the writer was checking the cotton survey in the Samrala Tehsil of the Ludhiana District, reports were received of the occurrence of a serious pest in the sugarcane fields of the " Bet " lands of the river Sutlej. On examining the affected canes, it was noticed that they were badly attacked by the parasitic plants of the genus *Striga*, natural order Scrophulariaceæ. Two distinct species were found and they have since been identified as *Striga densiflora* Benth. and *S. euphrasioides* Benth. They arise from the bases of the canes in large numbers and hundreds of these were found together at one place (Plate XXIV, fig. 1). They appear in clusters even at some distance from the canes but they have underground connections with them at the roots (Plate XXIV, fig. 2). The two species were met with in different fields. *S. densiflora* occurs in the villages of Shergarh, Fatehgarh, Makowal, etc., and *S. euphrasioides* has been found in the canes and *jowar* (*Andropogon Sorghum*) fields of Pawat village.

Bet lands are low but beyond the reach of the flood water and are very suitable for cane cultivation. The variety of cane grown is *katha* and is mainly cultivated within the first twelve or fifteen miles of the Bet. Sugarcane is an important crop in this tract but in some fields it has been ruinously damaged by the parasite. Many patches are seen in the fields where the canes have been killed by the pest.

The parasite is said to have been first noticed about seven years ago in the village Garhi which lies in the Patiala State territory. In Sherpur and Fatehgarh it has been seen now for three year.s

The canes attacked by the parasite remain stunted, their leaves wither and have the appearance of a drought-stricken plant. Some of the canes are totally killed by association of the parasite, while others have evidently withstood the attack and are affected very little (Plate XXIV, figs. 1 and 2).

It remains to find out how the parasite injures the cane. Several opinions are on record with regard to this problem. There is no mention, however, of any observations having been made on the parasitism of *Striga*. Both *S. densiflora* and *S. euphrasioides* are known as root parasites and as such they attach themselves by their roots to the roots of the sugarcane (Plate XXV). They suck the sap from the host which, being deprived of its nutrition, suffers from starvation and ultimately dies. In the "Dictionary of the Economic Products of India" by George Watt it is mentioned that "although no Indian writer has especially noted the direct attachment of the *Striga* weed to the roots of *Sorghum* or *Saccharum*, yet there is little doubt that it is in that way that the weed effects its destructive mission." In another place in the same book it is stated that the pest only appears when the land has been exhausted by over-cultivation. The exhaustion theory is refuted easily by the fact that as *Striga* appears in cane fields it must have some affinity and connection with this crop and not with soil alone. Similarly doubt is entertained regarding the parasitic nature of *Striga lutea* which grows on the roots of *jowar*, though it is proved that "if *jowar* is grown for a number of years successively the parasite continues to appear, and if cotton is planted on the same field it disappears."

The investigations dealt with here have been only recently started and good deal of work has yet to be done, but the few observations so far made will enlighten us on the parasitism of *Striga* and its relationship with the roots of sugarcane.

In the Samrala Bet sugarcane is sown in April-May and the parasite comes out in July-August. Many offshoots are given off from the underground portion of the stem of the parasite (Plate XXV, fig. 1). These offshoots pierce through the ground and come up. Cracks are seen in the soil where the new shoots are making their way upwards. From 15 to 30 offshoots have been counted on one

PLATE XXV.

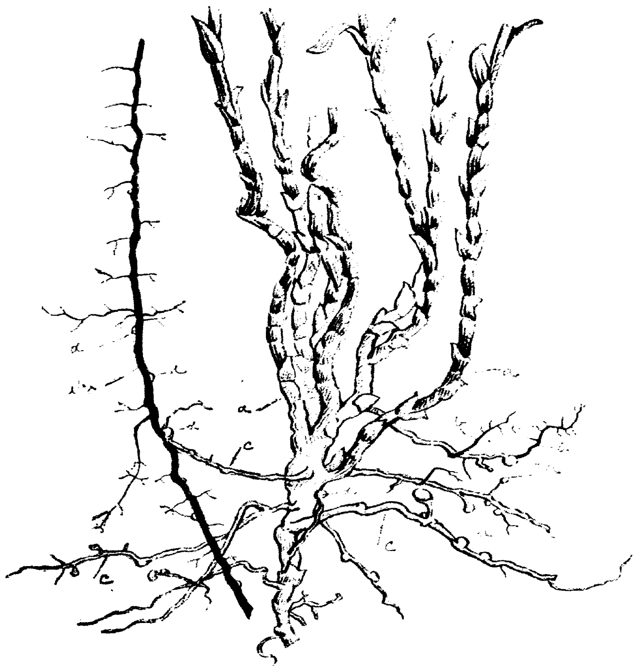

Fig. 1.

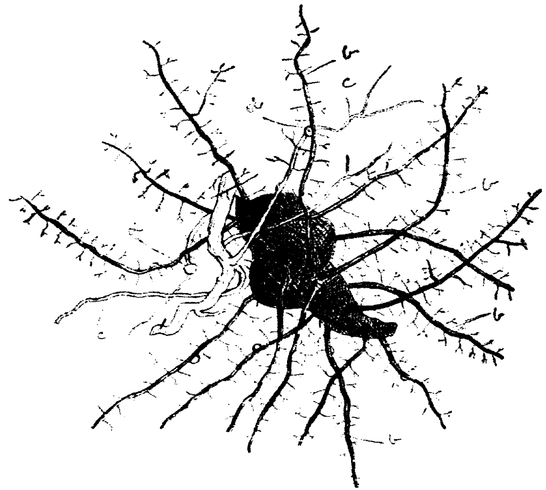

Fig. 2

(*a*), off-shoots; (*b*), a rootlet of sugarcane; (*c*), a rootlet of *Striga*; (*d*), haustoria.

STRIGA AS A ROOT PARASITE OF SUGARCANE.

PLATE XXV

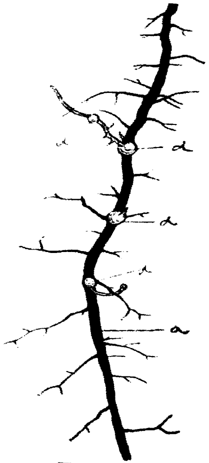

Fig. 1.

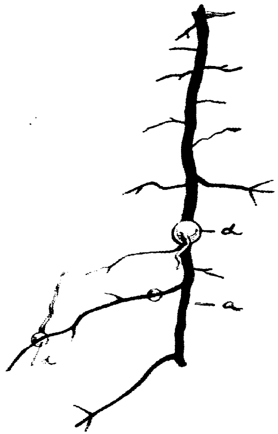

Fig. 2.

Haustoria on rootlets of sugarcane.

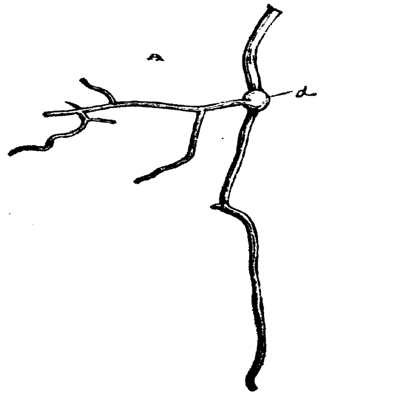

Fig. 3.

A rootlet of *Striga* bearing a haustorium

A

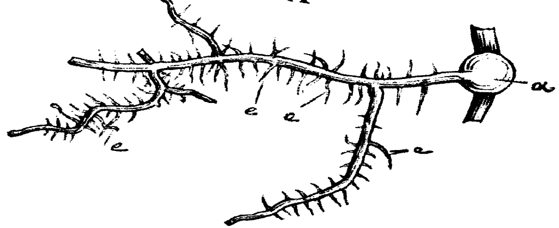

Fig. 4.

A part of a rootlet of *Striga* with root hairs (e).

plant of *Striga*. Fresh offshoots continue to arise till September-October. By this time older offshoots produce flowers and seed is formed. *Striga* comes to maturity in December and both the aerial as well as the underground parts altogether dry up. The seed is very minute and light. It is produced in large quantities in small capsules which burst longitudinally when dry and let the seeds go out.

There are 50 to 70 capsules on one shoot. A seed measures 0·3 mm. in length and 0·1 mm. in breadth. Myriads of these tiny seeds are liberated from the capsules and fall on the field, after the parasite has matured. The seed of the parasite remains in the soil and germinates if sugarcane is grown there in the next season. The parasite reproduces from seed and vegetative reproduction does not occur. Every part of it dies when its season is over. Generally the seeds of such parasites germinate at the time when the proper host is growing near by. The sowing of cane in fields already infected with the seed of the parasite would supply the necessary stimulus for its growth. In the case of *Orobanche indica* it has been found that its seeds do not germinate until tobacco or mustard or petunia is grown with it.

The characters of the two species of *Striga* examined are almost the same as those described by Hooker. Difference, however, is found in the height of *S. densiflora* which grows to a height of 30 inches against 18 inches as mentioned by Hooker. Leaves are small and green. Flowers are white, but they turn bluish when dry. The whole plant becomes black in dry condition. The cause of the wilting of the sugarcane in these cases lies in the root. If a cane and the parasite situated near it are dug out by the roots, it is found that the roots of both are mixed up in a tangled mass, but the roots of *Striga* are white and those of the cane are black and they can thus be differentiated from each other (Plates XXV and XXVI). Roots of *Striga* branch extensively forming a network of fine rootlets which closely invest the rootlets of the affected cane. The roots of the parasite bear a large number of white spherical nodules called haustoria (Plates XXV and XXVI). In some places they are present in rows. The haustoria are often found united with the rootlets of canes (Plate XXV). By means of these haustoria the

parasite secures its connection with the host and draws nourishment from it. Haustoria either arise freely from the parasite's rootlets or may become fastened on the roots of the host. They vary in size from one millimetre to three millimetres. Some of the haustoria send out thread-like processes. In one instance, two haustoria borne on adjacent rootlets of *Striga* have been found united. Rootlets of *Striga* bear root hairs also (Plate XXVI, fig. 4). The root hairs are comparatively few and are poorly developed.

The structure of the haustorium has been studied in a number of sections cut at various places. A free haustorium is made up of parenchymatous cells. The central region looks darker than the peripheral portion. The outer cells contain starch grains, and the cells in the centre appear to be full of protoplasm. The portion of the haustorium next to the parasite's root contains reticulately thickened xylem vessels. These vessels are connected with similar vessels in the parasite's rootlet. Probably nutriment for the haustorium is supplied through these vessels.

The haustorium on attacking the rootlet of cane brings about several changes in itself as well as in the host's root. In order to understand these changes we should first study the structure of the root of sugarcane.

A transverse section of its root shows the epiblema on the outside where root hairs are also seen. There is very little of cortical tissue. Almost the whole of the cortex is occupied by air cavities which are separated from one another by strands of tissue. The endodermis is well developed and its radial and inner walls are much thickened. The vascular tissue consists of xylem and phloem bundles which vary in number and enclose a pith. The presence of large air cavities shows that the roots of sugarcane are adapted to aquatic conditions.

The haustorium, when it invades a rootlet of cane, easily breaks through the cortex and comes to lie against the endodermis. The walls of the latter being strong and cutinised are not injured by the haustorium. At this point a process called the sucker develops from the haustorium and grows inwards. It ultimately ruptures the endodermis and penetrates into the vascular tissue. In the sections

passing through this portion of the attacked root the sucker can be traced right into the xylem. The reticulate vessels which extended up to the middle in a free haustorium are formed in the whole of it as well as are seen in the sucker. There is thus a continuous vascular tissue running through the parasite's root, the haustorium and the root of the cane, to conduct away the fluids from the host to the parasite.

Striga has green leaves which contain mesophyll tissue and chloroplasts. Being thus provided with the necessary means for carrying on anabolic processes it can elaborate its own food. While parasitizing on the host's roots *Striga* plants must be absorbing food materials from the soil by its root hairs. The *Striga* therefore comes in the category of semi-parasites. The existence of a few such parasites would not do much damage to the host, but as it occurs in thousands in a cane field the cumulative effect is very harmful. In the villages mentioned above it is prevailing to an alarming extent and unless preventive measures are adopted to check its progress it will spread to those areas where it is not present now.

As regards measures for its eradication nothing definite can be said at this stage of the study of the subject. But from our experience of other flowering parasites, *viz.*, *Orobanche*[1], it can be safely stated that the weeding out of the parasite by hand from time to time before its shoots flower would be very helpful in keeping it down. The parasite being removed before its seeds are formed the soil will not thus get fresh infection from the seed.

Cotton is not susceptible to the attack of the parasite and wherever possible its cultivation should be encouraged in place of sugarcane in the affected areas.

[1] **Shaw, F. J. F.** *Orobanche* as a Parasite in Bihar. *Mem. Dept. Agri. India, Bot. Ser.*, **IX, No. 3.**

SOME PRACTICAL HINTS ON THE MANAGEMENT OF ORCHARDS IN INDIA.

BY

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THE interesting and useful article on "Woolly Aphis" or the "American Blight," contributed by Mr. C. S. Misra, B.A., First Assistant to the Imperial Entomologist, in the November (1920) issue of "The Agricultural Journal of India", together with the valuable note of the Imperial Entomologist, has tempted me to suggest a few practical hints on the successful management of orchards in India.

It is indeed painful to observe that this serious insect pest, the "Woolly Aphis," first noticed in this country sometime in 1889, should have spread so rapidly and virulently as to become an object of alarm in most of the apple-growing districts in India. This, I believe, is due partly to ignorance and partly to negligence on the part of our Indian fruit-growers, and a few practical hints, therefore, may be of some service to the owners of orchards in India.

The first important thing that a fruit-grower has to bear in mind is to keep his orchard always clean, that is to say, he should see that it is free from rubbish, weeds, clumsy grasses, untidy hedges or fences, surface drains full of fallen leaves, dead twigs, etc., which offer secure shelter to insect pests of various sorts. Cleanliness, clean cultivation, is the essence of success in all horticultural business, and especially that of the fruit-grower. Keeping orchards continually clean should have a great value to the entomologist who desires to prevent the spread of insect pests in orchards. Cleanliness may not

have direct remedial values, but is surely a precaution against further growth and development of many of the formidable insect pests found so often in orchards, by eliminating their possible lurking places, where they hatch innumerable offspring, and whence they are ready to emerge at any time. Again, there are certain night-feeding forms, which must needs seek shelter for security during daylight, and their onslaughts may be minimized and kept under control, if their hiding places are permanently destroyed. *Constant* pests like "Woolly Aphis," the "Apple Sucker" or the "Codling Moth" may be got rid of or kept within control by taking direct vigorous measures against them: but there are numerous *occasional* pests which, although far less important individually, occur sporadically and irregularly on fruit trees, which by their total effect cause a serious loss to the crop. It is impossible to take any direct measures against each casual pest, since one never knows when they will occur, or whether they will occur, but something can be done indirectly to discourage their activities in an orchard by keeping it continually clean, thereby destroying all possible sources of their hiding places, where they multiply daily in large numbers.

The second important point that a fruit-grower has to note is a careful and judicious pruning of his fruit-trees at regular intervals. A correct and intelligent pruning in an orchard is as necessary as careful and intelligent planting. I say *correct and intelligent*, as I have seen hundreds of instances of very bad prunings at the hands of our inexperienced and illiterate Indian *malis* and workmen, who think that they are masters in horticulture, and can do all with a pair of shears once a year! Such reckless pruning would be even worse than no pruning at all, and should be discouraged everywhere.

While no hard-and-fast rules can be laid down for a correct pruning, it is safe to suggest the few following hints, which are applicable generally to all trees in an Indian orchard for their good and beneficial effects:—

1. Immediately the fruiting season is over, cut off, every year, all dried and weak stems, especially those which appear sick and diseased. By this mode the trees are much improved and

stimulated, and often encouraged to send forth new and healthy shoots with greater vigour and rapidity.

2. All barren trees in an orchard which have failed to produce fruits for a number of years require severe pruning, by cutting them hard back, retaining only the most vigorous and healthy branches. For the next two successive seasons, they should be left undisturbed, removing only the dried and decayed stems, if any.

3. The pruning should always be made with the aid of some *sharp* implement. Never use *blunt* shears or secateurs. The long-handled tree-pruners, which are made in various lengths, are unquestionably the most simple and useful implements in an orchard for pruning branches that are out of your arm's reach. For big and old branches, a pruning-saw is another very necessary tool, where pruning-shears or secateurs are not strong enough.

4. The cuts made by pruning should be as smooth as possible. For this reason two or three chisels of different widths should be kept in an orchard for paring the surface of any branch that has been cut with a saw, for a smooth surface soon heals over, whereas a rough one holds moisture, which frequently means the beginning of decay, and through such cuts fungi may enter the tissue of the plant. For this reason it is a wise precaution to paint over with coal-tar all cut surfaces in trees of more than an inch in diameter.

5. Never prune strong and healthy branches of an already fruit-bearing tree, as by doing this you will not only retard their progress of growth, but have every chance of doing substantial and permanent damage to the plant.

The next item for consideration to a successful fruit-grower is to provide a due and adequate supply of light and air in his orchard. A good and wholesome air with enough of sunlight and rain is equally necessary to keep the plants healthy and free from insect pests. For this reason, your fences should be as open as possible and practicable. Ideal woven wire fences, as advertised by Messrs. Burn & Co., are most suitable for all agricultural purposes and should be invaluable for the fruit-grower. If there must be hedges, let them be as open as possible, especially below. Of course, they should be sufficiently thick to be cattle-proof and protective against

thieves, yet there should be enough opening to admit a free circulation of air in orchards.

Overcrowding of trees in an orchard is another drawback to getting a produce of perfect marketable fruits without blemish. Every orchard should be started on the basis of this fundamental principle, by planting the trees at such distances as will prevent overcrowding on their attaining full growth. In old orchards, where trees are found to be too thickly planted and none producing perfect crops, they should be thinned out at intervals.

The fourth important thing for a modern successful fruit-growing business is the elimination of the grass-growing business completely from an orchard. The tillage of the soil under fruit-trees and between the trees has a great influence in keeping down pests. Where the fruit of an orchard is not the first necessity, grass may be grown under the trees ; but if the orchard is primarily for fruit of the perfect kind that sells well or stores well, permanent grass is a great mistake. Insect pests of various kinds coming from the tree find a secure shelter at the surface of the soil among grass stems ; some go deeper and get into the soil. Many caterpillars, in the intervals of feeding, shelter themselves amongst the grass around the trees, and some, when about to pupate, go deeper and penetrate in the soil. If there be no grass, they may be easily turned out and killed by tillage. But permanent grass prevents this from being done.

The last though not the least important thing for a fruit-grower is to have in his orchard always an adequate supply of suitable insecticides by which his trees are to be sprayed at regular intervals. Among the valuable insecticides may be mentioned tobacco solution, kerosine oil emulsion, lead chromate and various contact poisons. Of all these insecticides, lead chromate is of first rate importance in an orchard. For, lead chromate, properly made up, is a wash that remains on the foliage the whole year that makes it distasteful to all biting insects, *e.g.*, caterpillars, saw-flies, weevils, etc. It is a protective wash, and has a special value in keeping the foliage of fruit-trees immune from all this class of attack. To compose this valuable insecticide, you are required to add some soap, as simply lead chromate and water will not " wet "

the leaves of trees. If one part of lead chromate be mixed with 1,500 parts of water and some quantity of soap added just necessary to " wet " the leaves, it will probably make one of the most valuable insecticides for an orchard.

If a fruit-grower be cautious from the beginning, having, so to speak, a nightmare vision of an orchard as a place full of lurking insects ready to leap out of their hiding places at any time, if he would take enough care to keep the environment continually clean, to keep his plants always neat by careful sprayings, to give all the good of the soil, all the sunlight and rain to his plants, to avoid overcrowding, and to grow what he actually wants and nothing else, I am sure such dreadful insect pests like " Woolly Aphis " can never possibly take such a firm footing as has been sadly experienced by growers, but can be successfully kept under control without much trouble or expenditure.

Selected Articles

THE GROWTH OF THE SUGARCANE.*

BY

C. A. BARBER, C.I.E., Sc.D., F.L.S.

X. CONCLUSION.

IN the preceding articles of this series, various aspects of the growth of the sugarcane plant have been passed under review. We have traced the manner in which the seed germinates and forms the young seedling cane and have shown how the planted out set renews the growth of the parent plant, and in both cases we have noted the steps by which the mature bunch of canes is formed. We have dealt with the manner in which this plant, debarred by the absence of a cambial ring from increasing in thickness in a normal manner, builds up the cane thickness appropriate to the variety; and the two stages of growth common to all grasses have been discussed, whereby a foundation is first laid underground, consisting of an intricate network of stems, and when this is completed the end of each shoot thus formed is pushed into the air as a solid cane, often terminating in an inflorescence or arrow which puts a stop to its further elongation. Considerable attention is paid to the first, underground stage of growth, for this has apparently been neglected by former observers, and we have shown by means of dissections and diagrams that the branching system of the cane lends itself to expression by a simple formula, and that such formula, consisting of many terms in the wild species of *Saccharum*, gradually decreases in length as we pass through the various groups of indigenous Indian

* Reprinted from *Int. Sugar Jour.*, October 1920.

canes until, in the ordinary canes of tropical countries, the formula is very short and the intricacy of branching is reduced to a minimum. In a mature plant, it has been shown, not only that the individual canes are branches of various orders, arising in a regular manner after and from one to another, but also that the branches or canes of different orders have very definite characters by which we can at a glance distinguish them from one another. In late or early development, length and thickness of joint, rapidity of growth, ultimate sugar content and other characters, the canes of a plant often differ among themselves more than do the canes of different plants or, indeed, varieties ; and this accounts for the well-known fact that the cane crop arriving at the mill, even from a uniform field of one variety, often appears to be a very miscellaneous assortment in respect of these characters. We have concluded that it is idle to expect complete equality in such a case, as even in the same plant at crop time some of the canes will be over-ripe, others at their optimum, and yet others as yet unmatured. And we have pointed out that a good deal of work has still to be done before a scientific knowledge can be obtained of the correct time at which each variety should be cut, so as to obtain the maximum of sugar from it in the factory.

The parts of the cane above ground—leaf, stem and leaf-sheath—have been studied as to their growth and the curious fact has been noted that no two of those parts are found to be growing in length at the same time, suggesting that only a certain amount of growing energy is available and that this is switched on to the different organs in succession. The leaf elongates first, and not until it has reached its full length does the leaf-sheath extend itself, and this sequence is followed by the stem which only commences to grow in length when the leaf-sheath has fully developed. The length and thickness of the mature cane have been studied in different varieties and the effect of external conditions, especially on the latter, has been noted ; lastly, the whole question of tillering has been dealt with and the results of previous studies on this subject have been summarized. The factors which influence growth in all these directions, which play such a considerable part in the tonnage of canes at

PALMYRA TOPES IN THE MADRAS PRESIDENCY

harvest, have been analysed, in the hope that by their knowledge the way may be cleared for studies in increased output.

It will be obvious to the student of plant life that there are many other directions in which the growth of the cane could be discussed, and some of these form interesting matter for report and experiment ; but it is felt that the present series of articles will have already provided sufficient material for anyone interested in the subject to obtain a fairly clear idea of what goes on in the cane plant, whether in the soil or the air, and of the way in which the plant is built up from its small beginnings, and we have therefore decided to close the series as such, with the present paper.

At various points in our remarks, glimpses have been given of large series of measurements which have been made of the canes and their parts under the writer's direction, to obtain an insight into the way in which they behave under different conditions. One of the outcomes of this study has been the conviction that no one of the vicissitudes experienced by a plantation during the growing season, but leaves its mark permanently engraved on the size and form of the cane and its appendages. This should not appear strange to us when we remember that, by counting the rings of growth in a piece of wood, we can form a fairly accurate idea of how long it took to make it and, to some extent, the character of the seasons during its formation. Similarly, by carefully noting the shape and distance apart of the leaf scars in an ordinary shoot a history of its growth can be compiled for a series of years, the regular succession of spring, summer, autumn and winter, and we can even hazard suggestions as to the severity or mildness of some of these. As an example of quite another "interpretation of observed characters," a couple of photographs are given of palmyra topes in the south of India (Plate XXVII). In one case the normal growth of a plantation 60–70 years old is shown, while in the other some catastrophe has evidently happened, presumably a wind storm of unusual severity which has bent a number of trees at about the same angle, after which they have recovered their usual upright direction. Careful local enquiries elicited the fact that the storm took place about 28 years before the picture was recorded, because a domestic event of importance

occurred in the same year in the narrator's family. This record of experiences during the growing season is also to be found in the stem of the sugarcane, and a new interest has thus been infused into the dry and apparently profitless multiplication of laborious series of measurements undertaken for another purpose. A case has, indeed, been already given in which by studying abnormalities in the joint curves of the cane in a certain year on the Samalkota Sugar Station, a ready explanation was found when the details of the weather were looked up in the annual reports on the subject.

When at the founding of the Cane-breeding Station at Coimbatore, a larger number of North Indian canes were brought into the Madras Presidency, where the conditions are tropical and better suited to thick tropical varieties, it was thought worth while to make observations as to whether the change of climate would cause any observable alteration in the form and size of the organs. And a complicated series of exact measurements were instituted and taken year by year. Seven types were taken for this observation, and these were distributed to other parts of the Madras Presidency, and were subsequently studied wherever they were known to be growing on sugar stations elsewhere in India. Sets of measurements were thus obtained from ten different parts of India, and upon analysis of these it was found that not only had each variety a definite growth character of its own, but that each locality and soil had the power of modifying this, so that the growth in each place was the resultant of the inherent characteristics of the type, and the external environment to which it was subjected.

From the mass of material thus collected at or near harvest time, by trained subordinates in all parts of India, curves of length were prepared of the joints, leaves and leaf-sheaths, and tables were prepared giving averages of the most various other measurements. From a study of these data it was found to be not difficult to form an idea as to what variety of cane was being measured, and in what part of the country it was being grown. It was an easy step from this position to attempt to form an estimate as to the suitability of a variety to any given place, and also to form a general opinion of the suitability of any place for cane growth generally. This work has

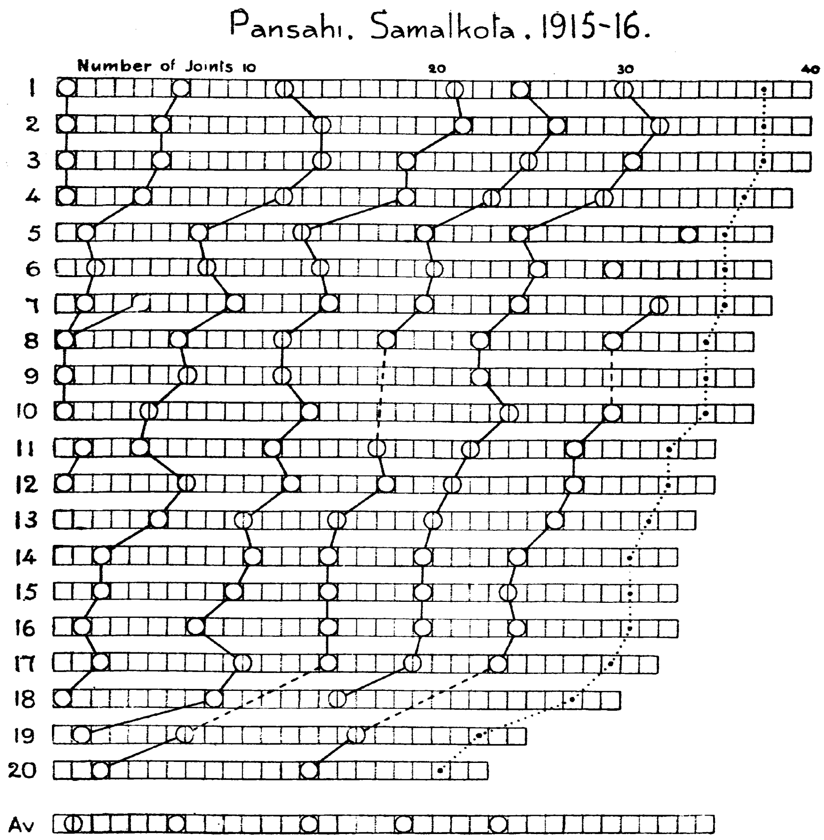

Fig. 1.

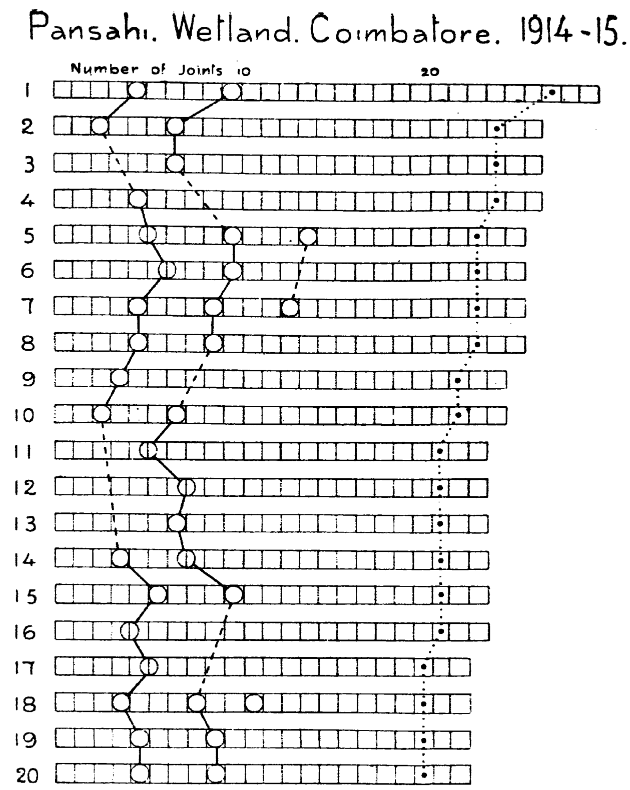

Fig. 2.

PERIODICITY IN MAXIMAL JOINT LENGTH OF PANSAHI CANES.

been briefly described in a paper by the writer,[1] and it is suggested that by this means a useful method has been devised for the study of cane growth in new tracts of country. It often happens that when the experimental plots extend over a wide stretch of country the task of examining the crops in all of them at harvest time is a severe strain upon the superior staff, and the results are likely to suffer because of this. It is also difficult for an officer rapidly passing through the country to keep rigidly to a uniform standard. But by relegating the observations to a fixed scheme of measurements by trusted subordinates, not only are these difficulties overcome, but there is a permanent record which may be referred to at any time, and which will be available for any new enquiry not at first contemplated.

Many points regarding the growth of the cane may be conveniently worked out with such a series of authentic records at hand. As an instance, when the idea of periodicity in the cane growth was suggested by certain curves of the length of joints, it was easy to push the matter further by inspecting the joint curves already worked out, and to add to their number from the table of measurements. It was observed that, in the Pansahi group of canes, many cases were met with in which zones of longish and shortish joints followed one another with some regularity. We have on several occasions in these articles referred to the fact that this group of canes, by the extreme regularity of their growth, have brought out points of general application which have been obscured in other groups of individual irregularities, and the present is no exception to the rule. While it was easy almost in any curve to detect evidence of periodicity in the length of joints in members of the Pansahi group, it was not at all easy in most other cases, but the subject had not been fully gone into when the writer left his work in India. Two specially well-marked cases are shown in Plate XXVIII, and the diagrams will require a brief explanation. The whole of the canes measured at one time and place are supposed to be laid down in front of the observer; each joint is represented in the plate by

[1] *Agri. Jour. India*, XVI, Pt. 2.

a square, and the longest canes are placed at the top, and those below with successively fewer joints. From our study of early and late canes we know that the former are characterized by having more joints, and the arrangement in the plate thus roughly corresponds with the order of development of the canes. A careful study is then made of the table of measurements of the length of the joints in each cane, and a mark is placed over the middle of any region of longer joints; these marks are represented by circles in the diagram. Lines are then drawn between maxima which are supposed to be related to one another in adjoining canes, and dotted lines are added where no such relation is traceable because of absence of maxima, merely to suggest the completion of the lines from top to bottom of the series. On the right of the diagram a further dotted line gives a general curve of the varying number of joints in the twenty canes, and it is noticeable that there is a strong tendency for the maxima lines to be parallel with these (see in Fig. 1, canes 3 and 4, 7 and 8, 8 and 9, 10 and 11, 12 and 13, 14 and 15), and this tendency has been used to influence the direction of the empirical dotted lines added in the diagram. The diagrams speak for themselves. Taking the most regular cane (No. 7 in Fig. 1) we have well-marked maxima in the 2nd, 5th, 10th, 15th, 20th and between the 32nd and 33rd joints, the maxima occurring at regular intervals excepting at the top and bottom of the cane, when local disturbances might be expected.

Whether the periodicity in growth of the cane thus brought out in the joint curves in Pansahi is due to an inherent periodic stimulus of growth or to some external cause cannot be determined without a full knowledge of the conditions of the crop during its full growth; it is natural to suggest that the explanation may be found in the regular waterings given, but if so, we are at once in difficulties: the waterings are far in excess of the maximal periods at some parts of the year, and are altogether absent during the time of the monsoon rains, and the other groups do not show regular maxima with anything like the same clearness.

A TURNING POINT IN THE WORLD'S SUGAR CONSUMPTION.

THE Continental Correspondent of "The International Sugar Journal" (XXIII, No. 268) writes :—

Since the year when the sugar production of British India was for the first time incorporated into the world's statistics, the world's sugar production (beet and cane combined) has been as follows expressed in long tons of 2,240 *lb.*

1904–05	..	12,022,000	1910–11	..	17,001,529	1916–17	..	17,096,828
1905–06	..	14,007,000	1911–12	..	16,064,391	1917–18	..	17,422,589
1906–07	..	14,799,000	1912–13	..	18,243,235	1918–19	..	15,858,265
1907–08	..	13,861,000	1913–14	..	18,430,873	1919–20	..	15,222,684
1908–09	..	14,582,165	1914–15	..	18,498,498	1920–21	..	17,302,510
1909–10	..	14,891,187	1915–16	..	16,968,003			

From these figures it will be seen that in the first decade of the present century the sugar production of the world oscillated around 14,000,000 tons and, since during so long a period no considerable stocks could have accumulated, the average consumption amounted to a corresponding figure. In the year 1910-11 there was a large increase in production, which was only temporarily interrupted by the disastrous drought in Central Europe of 1911, and it brought the total sugar production up to the astounding figure of 18,498,498 tons in 1914-15, the year in which the last crop preceding the war was sown and reaped.

For numerous reasons which are still fresh in our minds and need not be recapitulated, the European sugar production then decreased wholesale, and the deficit was only partially made good by an extension of the cane sugar production in some countries, among which Cuba was the most conspicuous. The world's total diminished each year, till it attained its lowest point in 1919-20 with

15,222,684 tons. In that year the general feeling was one of sugar scarcity and shortage, and it led to the phenomenally high prices recorded in the second quarter of 1920. But when comparing this low figure with those of the years composing the first decade of the twentieth century, one observes that it is higher than any one of them, and yet in those years we never heard of a scarcity of sugar.

This fact tends to suggest that if, now, the production of 1920-21 should, as seems probable, revert to the figures of 1910-11 (or only ten years ago), that production will be more than sufficient to cover the demand under the present day prevalent circumstances.

In the years immediately preceding the war, the civilized world was enjoying an unknown prosperity. Consumption of articles, which may, to some extent, be considered as a kind of luxury and among which sugar occupies a prominent place, increased considerably, a fact which may be deduced from the enormous increase in the *per capita* sugar consumption in many a European and American country. Therefore, in the years before the war, the increased sugar production was correspondingly absorbed by consumption, and this was so generally the case that in the calculations made by the sugar statisticians, the question of the consumption was treated as a secondary matter. The figures of production in the various countries were carefully studied and commented on, but it was taken for granted that, as a rule, the sugar produced would find a destination without trouble.

In the war years consumption remained high; the wants of armies and navies necessitated the supply of huge amounts of sugar, both in the shape of sugar for food and beverages as in that for confections, while some sugar also was used in the manufacture of explosives. After the armistice, a spirit of lavishness ensued all over the world, which, delivered from the prolonged oppression of war, indulged in every form of extravagance. The high wages accorded immediately after being claimed allowed wide sections of the population to spend money on extras, and it was remarkable to witness the extent to which grown-up people fed on chocolates, sweets, "acid drops," and the like. The price of the

article was not regarded as a hindrance to its being purchased up to the amount allowed by the Government rationing, which in many countries was far above the average *per capita* consumption of the years immediately before the war.

Further, people who during the years of war had witnessed periods of sugar scarcity, during which it was not possible to obtain the quantities which they might desire to purchase, now profited by temporary abundance to lay in stocks which at once disappeared from view. It looked as though there could not be produced enough to supply the ever-growing desire for sugar, and notwithstanding the fact that immense quantities of sugar, which owing to the blockades and general scarcity of merchant shipping had been held up in foreign countries, now became available, the visible stocks of sugar remained short. It is then no matter for wonder that statisticians neglected the study of consumption and only fixed their attention on the production, the increase of which was the aim and end of everybody concerned.

But during the last half of 1920 the free purchase of sugar by the general public came to an abrupt stop. Sugar was no longer snapped up in the market as soon as it made its appearance ; it was even offered in vain ; prices showed an inclination to drop, and that precipitated the trouble. The public who, in many cases, possessed appreciable quantities of sugar hidden in their store cupboards, stopped buying and lived on their supplies. The grocers stopped their orders and the wholesale dealers, who had already contracted large purchases, became overstocked in consequence. Thus all at once, instead of a sugar scarcity, there ensued an abundance of sugar (coming from every part of the world) with very restricted purchases and consequently a heavy drop in the price.

By now the invisible supplies will have been consumed, and the public will again have to buy if it wants sugar ; but, in the meantime, the general aspect of matters has greatly changed. Instead of high wages and good earnings, unemployment has become the chief factor that rules the budget of the average household. As we have pointed out above, sugar is one of the articles the consumption of which is greatly dependent on the earnings of a large proportion of

the population. So long as the wages were high, sugar was bought and used in great quantities, but as soon as more economy had to be practised, it was the first article to be sacrificed.

During January 1921, the revenue from the sugar tax in France yielded 23,115,000 francs less than that of the corresponding month in 1920, or 25,000,000 francs below estimates. This follows suit with the decrease reported from the same country in the months of September-December, in which the revenue from that source was 199,315,000 francs in 1919-20 and only 101,213,000 francs in 1920-21. In the last-named period we could still count on invisible stocks being consumed, but as late as January these would have disappeared, so the figure given for January tends to represent the real consumption.

The revenue from sugar in Holland was for January-February 1921 only 7,274,976 guilders, against 9,680,127 in the corresponding months of 1920. Since a year ago there was no reason at all to suppose an abnormally large consumption, the figure given for January and February 1921 points to a decrease in consumption in Holland, too. Again, during the ten months April-January 1920-21, Germany received from the sugar duties 101,963,250 marks, against 140,241,861 marks in the corresponding months of 1919-20. The total yield for 12 months was estimated at 160,000,000 marks, so that the remaining two months will have to supply 58,000,000 marks to reach the estimated figure, which is, of course, quite out of the question.

The same or analogous reports reach us from every part of Europe and show that a general decrease in sugar consumption is the rule everywhere. Finally, we must not forget that Russia, which in former and better years used to consume, aided by her adjacent neighbours, a total production of close on 2,000,000 tons per annum, does not consume now more than the low quantity of its own crippled production, estimated at some 100,000 tons.

We must, therefore, bear in mind that whereas the sugar production of 1920-21 will attain to about as high a figure as that of 1910-11, one great country, which in the last-mentioned year consumed about 2,000,000 tons, has fallen out almost completely, while the

consumption of many others is greatly handicapped. The conclusion to be drawn from all these data is that the day has surely passed for the time being when any amount of sugar produced is sure to find an outlet; and the question of the probable world's consumption will once more have to be taken into earnest consideration.

RESEARCH IN ANIMAL BREEDING.*

BY

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I

WHEN Mendel's discovery in heredity, made over 50 years ago, was unearthed in 1900, it was at once clear to a few scientific men that a new era in the breeding of animals and plants had commenced. What the breeder requires is " certainty " in so far as it is possible to attain it. When a given mating is made he wishes to know what is likely to result, and further, as he is generally of an intelligent and inquiring mind, why the result is obtained.

Through Mendel's work and its recent development the breeder is at last being placed in a sound position to answer these questions. Plant breeders have not been slow to take advantage of the new knowledge. Realizing early the immensely greater powers of control over the living thing conferred upon them by Mendel, they set to work to build up new strains of cereals and other valuable plants. It is unnecessary to detail here the remarkable success which has already attended their efforts, nor to forecast the enormous economic gain that must come to the world when the methods are applied to the produce of vast tropical areas. The rapidity with which plant breeding stations are springing up in both hemispheres is evidence of the service which Mendel rendered to mankind.

While, however, the plant breeder is now fairly embarked upon his career of conquest, the breeder of animals tends to lag behind. Nor is this difficult to understand. The majority of plants are self-fertilized. It is an easy matter to obtain the pure strains essential

* Reprinted from *Jour. Min. Agri.*, XXVIII, No. 1.

for purposes of Mendelian analysis, to keep them pure, and to purify any desirable new strain that may be built up. Animals with their bi-sexual mode of reproduction are far more complicated things to deal with, and, as we shall see later, the separation of the sexes may in itself introduce complications peculiar to this mode of reproduction. Then again, plants are cheap owing to their great powers of multiplication. Thousands of wheat plants may be grown for the cost of a pig. This rapid multiplication of plants renders more easy the process of Mendelian analysis, and, in consequence, man's power of control over them is enhanced.

It was proved years ago that Mendel's principles of heredity apply equally to animals and plants, and the importance of the subject led the Board of Agriculture some years ago to set aside a small grant from the Development Fund for research in animal breeding. The sum allotted, less than £200 per annum, only allowed of work being undertaken with small animals such as poultry and rabbits, but this in itself was no disadvantage, for the object of the work was not to improve the breeds of rabbits and poultry, but to acquire knowledge of the laws which underlie inheritance in animals generally. In this series of brief articles an attempt will be made to indicate the drift of these experiments, and their possible bearing upon economic problems. Before doing so, however, some account must be given of the nature of Mendel's discovery itself; this is the corner stone of our present knowledge, and unless it is clearly understood later developments must prove unintelligible.

The essence of Mendel's discovery may best be made clear by a simple example, from cattle. The breeder knows, perhaps only too well, that red calves are apt to appear occasionally even in the most highly pedigreed breeds of Aberdeen, Angus or Holstein. They are rarely welcomed, and in most cases the breeder would go to a great deal of trouble to ensure that they never appeared in his herd. He tries to get rid of the taint by vealing the red calves, but still they come from time to time. He may try to explain their appearance as a throw-back to some remote ancestor, and though this may ease his conscience it does not help to purify the herd. Mendelism enables the breeder to understand why these red calves appear, and

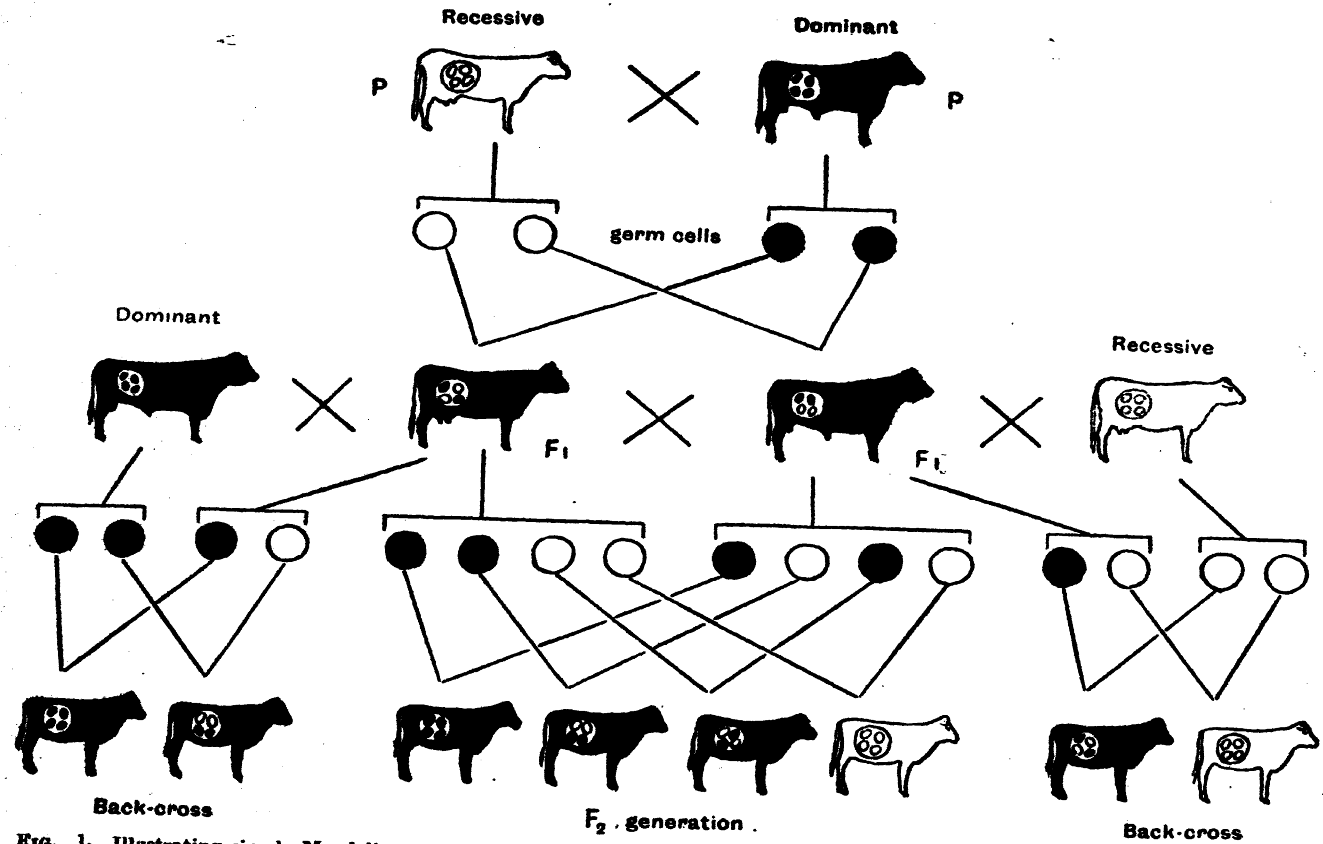


Fig. 1. Illustrating simple Mendelian inheritance in a cross between red (recessive) and black (dominant) cattle. The nature of the germ cells carried by each animal is indicated inside the circle on its body.

provides the knowledge which can be used to prevent their ever appearing again.

Let us suppose a Mendelian analysis of this case to be made in the usual way. The first step is to cross the red with the black, and it will be found that the pure black bull crossed with red cows will produce black calves only (Fig. 1). For this reason, black is said to be dominant to red, which is recessive. The next step is to mate together these first crosses, or F_1* animals as they are termed. It will be found that their progeny, the F_2 generation, consists of both blacks and reds, but not mixtures of the two colours, and if a sufficient number have been reared, it will be found that the blacks are about three times as numerous as the reds. To cover such facts Mendel devised simple explanation in terms of germ cells. Red and black are alternative in heredity because they are alternative in the germ cells. A germ cell contains *either* that which causes the development of black pigment or something which causes the development of red pigment; but it is in the order of nature that it cannot contain both. It is not known at present what these contents are, but as their existence is recognized a name must be given to them, and they are usually spoken of as *factors*. A germ cell, in our cattle then, contains either the factor for black or the factor for red. When an animal breeds true to a given character it means that all its germ cells carry the factor for producing that character. All the germ cells of a true breeding black contain the factor for black, and all the germ cells of a true breeding red contain the factor for red.

Let us refer again to the diagram (Fig. 1). If a red cow is crossed with a black bull, a " red " germ cell from the cow is being united with a " black " germ cell from the bull. The resultant animals will be black because black is completely dominant over red. but although it is black it is not a true breeding black. When such an animal reaches maturity it produces germ cells corresponding to

* For the sake of clearness in experimental work the cross is taken as the point of departure. The first cross animals belong to the first filial = F_1 generation. When F_1 animals are mated together they produce the second filial or F_2 generation. F_2 animals mated together give a third filial or F_3 generation, and so on. Similarly in the other direction the parents are labelled as the P_1 generation, the grandparents as the P_2 generation, and so on.

the germ cells by which it was produced itself. In their formation the red and the black factors separate cleanly from one another, and in consequence half of its germ cells contain the black factor and the other half contain the red factor. The F_1 animals, therefore, whether bulls or cows, produce " red " and " black " germ cells in equal numbers, but owing to the complete dominance of black, they are indistinguishable from true-breeding blacks in appearance. Their genetical constitution, as indicated by the output of germ cells, is very different. The nature of the germ cells produced is diagrammatically represented in Fig. 1 by the contents of the white circles on each animal. When two F_1 animals are mated, two similar series of germ cells, each consisting of equal numbers of the "red" and " black," are brought together.

Normally only a single ovum of the series produced by any individual cow will be fertilized, but the probabilities are equal of this being a " red " or a "black " ovum. If it is a " black " ovum it is equally likely to be fertilized by a " black " or a " red " sperm. In the former case it will give a true-breeding black : in the latter it will give a black of similar nature to the F_1 animals. If it is a " red " ovum it is also equally likely to be fertilized by a " black " or " red " sperm. In the former case it will give a black of similar nature to the F_1 animal ; in the latter case it will produce a red. In considering the calf thrown by an F_1 cow mated to an F_1 bull, the possibility of its being red is 1 in 4, of its being a true-breeding black 1 in 4 and of its being an impure black (*i.e.*, a black that produces both " black " and " red " germ cells) is 2 in 4. If a large F_2 generation from a number of F_1 cows mated to F_1 bulls were raised, we should expect the F_2 generation to consist of blacks and reds in the proportion 3 : 1 ; further, of the blacks, only 1 out of 3 would breed true to black in the sense of producing only black germ cells. The others would act like the F_1 parents and throw about 25 per cent. of reds if mated together.

The truth of Mendel's interpretation can be further tested by mating what are called " back-crosses," *i.e.*, by mating the F_1 animals back to the parents. Suppose, as is shown on the left of Fig. 1, that the F_1 cow is mated to the pure black bull. As the cow's

germ cells are of two kinds, " red " and " black," and those of the bull are all black, we can obtain only two sorts of animals, *viz.*, those formed by the union of a " black " ovum with a " black " sperm, and those formed by the union of a " red " ovum with a " black " sperm. The progeny will be all black in appearance, but while half of them are true-breeding blacks the other half will be capable of throwing reds when suitably mated. Again, if the F_1 animal is mated with the recessive red as shown on the right side of Fig. 1, the germ cells of the F_1 being " black " and " red " in equal numbers, and the germ cells of the recessive being " red," red and black among the calves would be obtained in equal proportion. Moreover, all the blacks so produced would be of the same constitution, *i.e.*, they would have the same output of germ cells as the F_1 parent. No true-breeding black would come from such mating.

For the information of the breeder, the substance of the matter is that when a definite pair of alternative characters is being dealt with, of which one is dominant and the other recessive, only three classes of animals are possible : (1) the animal produced by the two *like* germ cells, both carrying the factor for the dominant character ; (2) the animal produced by two *like* germ cells, both carrying the factor for the recessive character ; and (3) the animal produced by two *unlike* germ cells, one of which carries the factor for the dominantt and the other for the recessive character. (1) is the true-breeding dominant, (2) the true-breeding recessive, and (3) the impure dominant, which, though like the pure dominant in appearance, differs constitutionally from it in producing both " dominant " and " recessive " germ cells in equal numbers. The true test of the pure bred animal is that it breeds true, and this we cannot tell from its appearance, but only from the nature of the germ cells that it produces. Mendel's advice to the breeder is : " Think in terms of germ cells."

If the breeder wishes to prevent the appearance of reds in his herd he must eliminate the red germ cells, as these may be carried by blacks as well as by reds. The impure dominant blacks must be weeded out in order to be sure that red calves will not appear. Through Mendelism there is now a definite test that can be applied

to determine whether the black is pure or not, and that test is to mate with the recessive; so mated, the true-breeding black will produce only blacks, while the impure dominant will produce an equal number of blacks and reds. This, of course, is a policy of perfection, and unlikely to be put into practice. Cows in a pedigree herd are too valuable to devote an appreciable proportion of their progeny to testing operations. But since red calves are never born of blacks, unless both parents are impure dominants, it is clear that the use of a bull which had been tested by mating to red cows, and shown to produce only black progeny, would be sufficient to prevent the appearance of red calves in a herd, whatever the proportion of impure dominants among the cows. In practice, therefore, the breeder would be well advised to make sure of the bulls by testing them, even though he did not trouble about the cows. But although nothing but blacks will be produced, the red germ cells will still be scattered about in some of the cows. He cannot be sure, without testing, that an animal sold out of the herd will be a pure black. Nevertheless, if he makes use only of tested bulls the proportion of impure dominants among the cows will gradually decrease, and the possibilities of any beast sold being a true black will increase correspondingly. If, however, he uses a new bull without testing it, and it happens to be an impure dominant, a considerable increase must be expecte din the number of red calves in later generations, for such a bull introduces as many "red" germ cells as "black" and must necessarily increase the proportion of impure dominants in the herd.

The breeder may reason that, provided the animal brought into the herd had a good pedigree, why should further trouble be taken? If its ancestry shows an unbroken line of blacks for, say, the last 10 generations, is it not practically certain that none but black calves will be thrown? The answer is that pedigree is certainly *some* guide to breeding capacity. An animal with a line of black ancestry is more likely to be a true-breeding black than one that has a strain of red in its pedigree, but it is not a sure guide. The "red" germ plasm may be carried on by blacks for many generations, without coming into the open in the form of a red calf. This is

illustrated by the imaginary pedigree shown in Fig. 2. The impure dominant cow in Gen. I carried "red" germ cells, and the "red" germ plasm passes down to her daughter, grandson and great granddaughters.

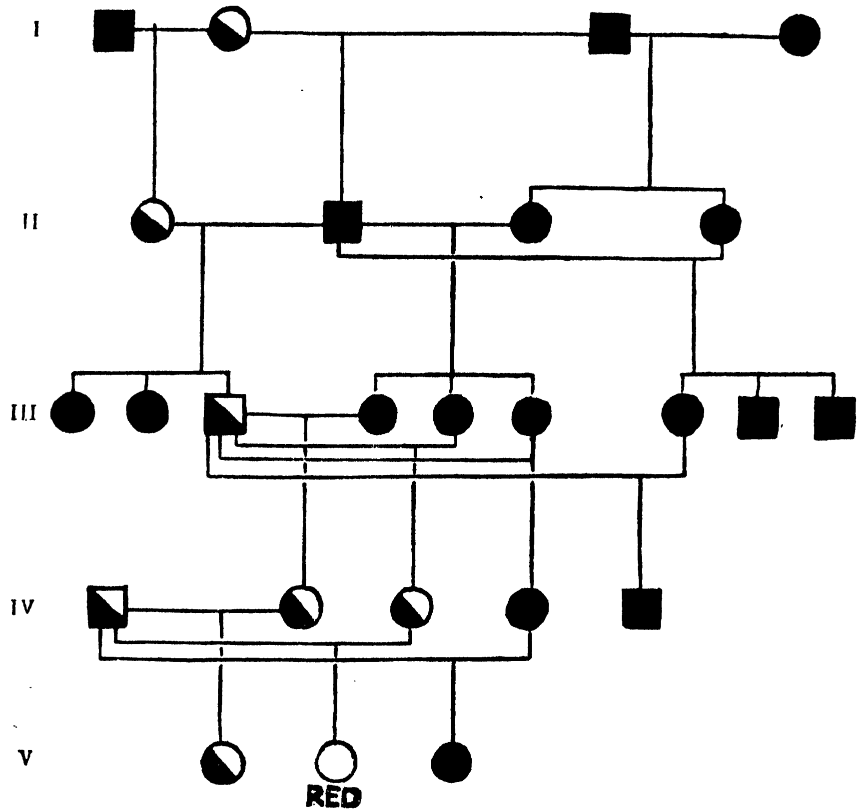


Fig. 2. Illustrating an imaginary pedigree of black cattle. Bulls represented by squares: Cows by circles. True breeding black represented by full black: impure dominants—carrying red, represented half black and half white.

No red calf appears because all of these animals, except the last, have been mated with pure dominants. But at Gen. IV, a new bull is introduced which turns out to be an impure dominant, though it may have had only black in its pedigree for generations. If one of the great-granddaughters of the original cow is mated to this bull, it will produce a red calf in Gen. V. Had the breeder tested the bulls used in Gen. III and Gen. IV by mating them with red cows a proportion of red calves would have been thrown. Had

he then substituted for these animals bulls which threw only black calves to red cows he would have broken the sequence of the "red" germ plasm and established a true-breeding strain of blacks. Pedigree is a rough guide in estimating the possibilities as to whether the black belongs to the class of true-breeding blacks, or to that of the impure dominant blacks, but *certainty* as to the nature of the animal can only be arrived at by the direct test of mating to the recessive red. By using only tested bulls the breeder can be sure that none but blacks will appear in his herd. The true test of the purity of a given animal for a given character is not in its pedigree, but the nature of the germ cells that it produces. We now have a reasonable explanation as to why the "pure bred" beast may be nevertheless in reality an impure dominant.

The relation between the animal and the germ cells that it produces is the essence of Mendel's discovery, and must in future form the basis of the breeder's operations where purity of breed and character is desired. Where the character depends upon a single pair of factors, as in the black-red cattle case, the procedure for ensuring purity is simple ; and there are a number of such simple cases in connection with farm live-stock. Many of these concern coat colours because they are evident and easily worked out. The polled and horned characters in cattle form such an alternative pair, the latter condition being recessive.* Horned animals appear in polled breeds in precisely the same way that reds appear in black breeds, and the procedure for ensuring a herd true to the polled condition is the same as that for obtaining a herd of blacks which throws no reds. Further, Suffolk sheep are liable to throw inferior lambs with brownish markings in place of black. Records suggest that this character behaves as a simple recessive, and could be eliminated by the usual procedure.

The characters that breeders are concerned with are rarely so simple and distinct as the black-red case in cattle, for the possibilities rarely form a simple alternative pair as already described. Usually they are far more complicated, and all kinds of gradations are possible. Hence arises the question, whether

* Polled animals carrying the horned character sometimes show small "scurs".

such complicated cases can be resolved in terms of a few definite factors showing a similar scheme of transmission. Will the general principle of heredity outlined above serve to cover the more complicated cases ? Is Mendelism heredity, or is there any other kind of inheritance ? These questions will be dealt with in the next article.

CONTOUR DRAINS OR CANALS ON HILLSIDES.*

BY

F. D. DAVIES.

DURING the past five years much attention has been given here to this subject under the more popular name of "Contour Drainage." Unfortunately, the term "draining" is considered by many to mean only the letting off of superfluous water. The value of letting air and warmth into the soil as well as conserving moisture for the benefit of plant and animal life, which requires regular and fresh supplies of these, is seldom considered.

The belief that draining is only necessary for letting off water is erroneous, and leads to very great loss, by causing the same system of draining adaptable to flat land to be used on hillsides. So much importance is attached to the letting off of water, that drains on hillsides are generally considered unnecessary by some, and by others necessary only in so far as the letting off of water is concerned, resulting in the system of digging main drains down the hillsides and steep side drains leading into them. In some cases an excessive amount of shade on a hillside may render the soil cold, when the reason is attributed to too much water, although this apparent excess of water may be due to the absence of sunlight or the absence of proper soil conditions ; which latter condition arrests the percolation of the water within a couple of inches below the surface of the soil.

On lowlying lands where water actually collects, or is liable to collect in pools or to such an extent as to block the air passages

* Paper read before a meeting of the Windward District Agricultural Society, Tobago. Reprinted from *Pro. Agri. Soc. of Trinidad and Tobago*, March 1921.

through the soil, draining is necessary to get rid of the water and to allow air and warmth to enter ; and to do this effectively the drains must have as much flow as possible. In some cases, according to the level of the land in comparison with that of the sea, this operation may necessitate sluice gates, pumps, etc.

The soil is composed of small particles of irregular shape and size—clays having over a million and sands several thousands per cubic inch—these are so arranged as to leave small spaces or tubes between them. When these tubes are filled with water, air is excluded, and such conditions if prolonged cause acidity injurious to plant life and beneficial bacteria in the soil. As soon as the water drains off, air and sunlight are let in. These counteract acidity, convert inactive plant-food into active plant-food and supply oxygen, nitrogen and carbonic acid gases for the use of plant and animal life ; and in order to get the best results from the soil the continuous interchange of these elements is indispensable.

Water is heavier than air and according to the law of gravity must find its level provided that it is not obstructed by some impermeable substance ; therefore, provided the soil is loose enough, the water passes through and percolates downward until it reaches its level, after the soil has absorbed as much as it can retain, along with a moderate supply of air. As soon as this absorbed water is used up, fresh supplies are attracted from the surface of the surplus water by capillary action ; the quantity so attracted depending on the size of the capillary tubes or spaces referred to above and the distance the water has to travel ; consequently, clays, having smaller spaces, benefit more by capillary attraction than sands ; and lowlying lands more than high elevations. It stands to reason, therefore, that we cannot depend on capillary attraction on steep hillsides to the same extent as on flat land, since water would rise only to the nearest point of least resistance, *i.e.*, the valleys ; and as rainfall is the only other source of water on hillsides, instead of using a system of draining to let water out we must try to retain it in the soil. For this reason I have not used the term "Contour Draining" as a title to this article, in the hope that the familiar

meaning "draining" generally conveys—that of letting out water—will be forgotten whilst dealing with hillsides.

Here, our land is a series of hills with slopes inclining in all directions, separated from each other by gullies and indentations of various depths and widths, caused by storm water flowing in the same course annually. The commencement of these gullies is in many cases gentle, but the gullies increase in size as the area of land from which the water flows into them is increased, in some cases forming precipices, pools, etc. The soil on these slopes is generally fertile when first worked up, but rapidly becomes impoverished in proportion to the steepness of the hillsides, on account of the enormous loss caused by erosion. The hills are not very high, and generally a hillside is owned by one or two peasants or entirely by a large estate, which is a valuable consideration when digging contour drains, as in cases where the head or commencement of a gully can be controlled the whole may be filled up, thereby saving the most valuable parts of a field.

Contour drains, as their names imply, are dug according to the lay or contour of the land, horizontally across the slopes of ridges and indentations. They may be divided into three kinds, *viz.*, (1) level drains without an open end, in which all the water collected remains and filters through the soil, (2) level drains with one or both ends open which allow the water to flow off as it rises in the bottom, and (3) slightly graded drains with a flow of not more than one foot in one hundred and twenty feet which do not allow the water to rise or remain in them. The level drain, unless passing through very porous, shallow soil or touching a natural water course or irreclaimable gully, need not have the ends opened; consequently they are sometimes termed "blind" drains. These blind drains have a decided advantage over the others on very dry hillsides with slopes of from ten to twenty-five feet in one hundred feet, inasmuch as all the water is retained. The level open-end drain suits very porous soil which does not allow the water to flow off the surface too rapidly, and particularly hillsides with slopes of from five to ten feet in one hundred feet. The graded drain must have the end towards which it flows open into a natural water course or drain made for the

purpose; this kind of drain particularly suits hillsides with slopes not exceeding five feet in one hundred feet and shallow soils which rest on some impermeable stratum; if, however, this stratum can be dug into so as to have the bottom of the drain formed therein, the level open-end drain would be much better.

The size of the drains and the distances at which they are placed apart depend on the ability of the soil to absorb water, and the usual rainfall of the district. Ordinary drains 18 inches wide and 18 inches deep, placed at distances of 36 feet apart (about three rows of cacao), are generally dug. This size is calculated to hold a continuous shower measuring two inches of rain. Stiff clays should be drained every 24 feet or even closer where practicable as they are more retentive. The object is to prevent overflow to any great extent and also the water from remaining for a longer period than four or five days in the drain. Where overflow appears likely to occur, the remedy is to increase the size of drains by making them two feet wide and two feet deep or to reduce the distance apart, but under no condition should a drain be cut up and down the hillside through the contour drains. Lighter soils are best dealt with by digging the first drains 36 feet apart, during the next year these are cleaned after the heavy rains and a new drain dug 12 feet below the first; in the third year another is dug 12 feet below the second drain and the first and second drains cleaned out; the stuff and soil removed being spread on the land, covering all exposed roots. If the land can be forked also, drains may be put in at 24 feet apart and cleared twice per year, but where forking is not possible, the above system of digging a new drain every year is better. In this way the field will be drained every 12 feet apart, and the drains should be regularly cleared once or twice a year and the soil spread on the surface of the land each time. In the fourth or fifth year the first year's drains should be filled up with manure, leaves, prunings, etc., and a new one opened about one or two feet above the one filled up, and the process repeated every one or two years as practicable. This also ensures an effective and safe system of root pruning, care being taken not to cut a drain closer than three feet to the trunk of a tree. Whenever possible,

canavalia or other leguminous plants should be sown on the filled up drains. If this system is followed the expenses of forking can be reduced to a minimum.

Contour drains can safely be dug on hillsides with a slope of 25 feet in 100 feet. The steeper the hillsides the more rapidly water passes off, and consequently the more necessary are the drains. In places where landslides are likely to occur, a safe preventive measure is to pass a drain about five feet above the place where the landslide is expected, giving this portion of the drain a gentle incline until the threatened area is passed ; and similarly care should be taken to pass one above every precipice should these be present, to prevent further wash.

Having decided the size of drains required and the distances apart at which they are to be placed, start from the highest part of the field. If a large area of land is above which is not required to be drained, the first drain must be much larger than the others, and must open at one end into a natural ravine if available, in order to take off excessive storm water : the drains should then be traced and picketed. A road tracer will be found very useful on large areas, but small fields can be done with the eye. With the fork, break the upper side of the drain in a sloping manner so as to avoid caving in, until the place for the drain is levelled, care being taken to prevent the soil broken away with the fork from going down the hillside. The drain may then be dug the desired width and depth ; the earth removed should be spread as a covering or mulch over the field. It is unsafe to bank up the soil on the lower edge of the drain, as unless the drain is well formed into the soil, the water would escape through the banked up earth and probably result in the bursting of every drain below. In case of a tree, stone, or any other obstacle lying in the course of a drain the drain can be abruptly stopped and commenced on the other side. Owing to the system of lining up and down the hillsides, the obstruction is unavoidable, but it would appear advisable, in view of the growing importance of these drains, to line new plantations according to the contour of the land. A drain, provided it is a level one properly traced, can be continued for any length, in and out of indentations. In this way

the water is prevented from flowing downward into the gullies, which could gradually be filled up. When drains are graded they should not be longer than 1,800 feet, unless the flow is gentler than 1 foot in every 200 feet, inasmuch as the rapidity of the flow increases nearest the outlets in proportion to the length.

Where the land is a series of ridges one higher than the other, the highest point should be started first ; the first drain may be short, not touching the indentation between the first two ridges, the second may be longer touching the head of the indentation, while the third may pass through the indentation on to the second ridge ; and so every consecutive drain may be lengthened as the width of the field increases. It is possible in draining large areas that different classes of soil may be met up, such as a light sandy soil with clay on both sides. It would be advisable in such cases to stop the drain within five feet of the sandy soil on each side, as the sand being porous would allow the water to flow through it more rapidly than the clay. This does not mean that sandy soils should not be drained, for in many cases they may be bound up with roots to such an extent as to exclude the free passage of air and water. It may be seen from the foregoing that water collects in the drain and stays there according to the stiffness of the soil, but in no case have I known it to remain there longer than four or five days, and it could only do so if the drain is in impermeable dead rock, when, as mentioned before, it would be more advisable to open one end. The drains being parallel to each other render the distance at all points more or less equal, and the air passages of the soil being opened by each drain the water percolates from one to the other.

Everyone is familiar with hillsides that get baked in the dry season and slippery when the rains fall. In many cases this slipperiness is considered to be due to excessive moisture, but by digging a hole into such soils it can be conclusively proved that this water is merely held by the first three or four inches. The soil being hard and steep the water rushes away before it can be absorbed, especially in the dry season when an occasional shower falls and when hillsides are more in need of water. When contour drains are dug all the water is retained and the greater part is absorbed by the soil ; this

causes the plant roots to penetrate deeper down into the soil, thus saving the loss of thousands of dollars from the effects of drought. Incidentally, all the nitrogen washed from the air by rain is retained, and the heaviest source of loss to the soil, that of surface erosion, is checked.

Next to the importance of conserving water is the conservation of plant-food on hillsides, and to do this we must adopt some means by which surface erosion may be checked. Plants cannot take up soil, but only certain substances contained therein that are soluble in water. The surface layers are richer in these on account of their exposure to the atmosphere, and these surface layers form that part of the soil most readily washed away in rain water passing over the surface of the land and flowing into ravines and gullies. This water, generally muddy with suspended soil particles, evidently takes with it large quantities of the soluble substances required by plants, and, if arrested at its source, the hillsides, by contour drains, becomes filtered, with the result that any portion reaching the ravines is no longer muddy or even discoloured. This shows that the suspended particles are retained, and as most of the water is in this way absorbed by the soil, but little plant-food is lost. Several experiments with artificial fertilizers on hillsides have failed to give beneficial results, although other conditions favoured their use, and in this surface erosion, as well as in the inability of the soil to receive and retain sufficient quantities of water, lies one of the chief reasons. Water without food and air, nor food without water and air, cannot give the best results.

The method of terracing, as practised in the Southern States of America, where, however, machinery is used on hillsides with slopes ranging from 3 feet in 100 feet to 15 feet in 100 feet, is described by Mr. C. E. Ramser, U. S. Department of Agriculture, in an article entitled " Terraces How and Where to Build Them " reproduced in " The Tropical Agriculturist " for February 1920. The writer points out that considerable wash or erosion takes place on hillsides with so gentle a slope as 6 inches in 100 feet, and describes the different forms of terraces practised, including level terraces " which retain the water until it is evaporated, sinks into the soil or finds its way

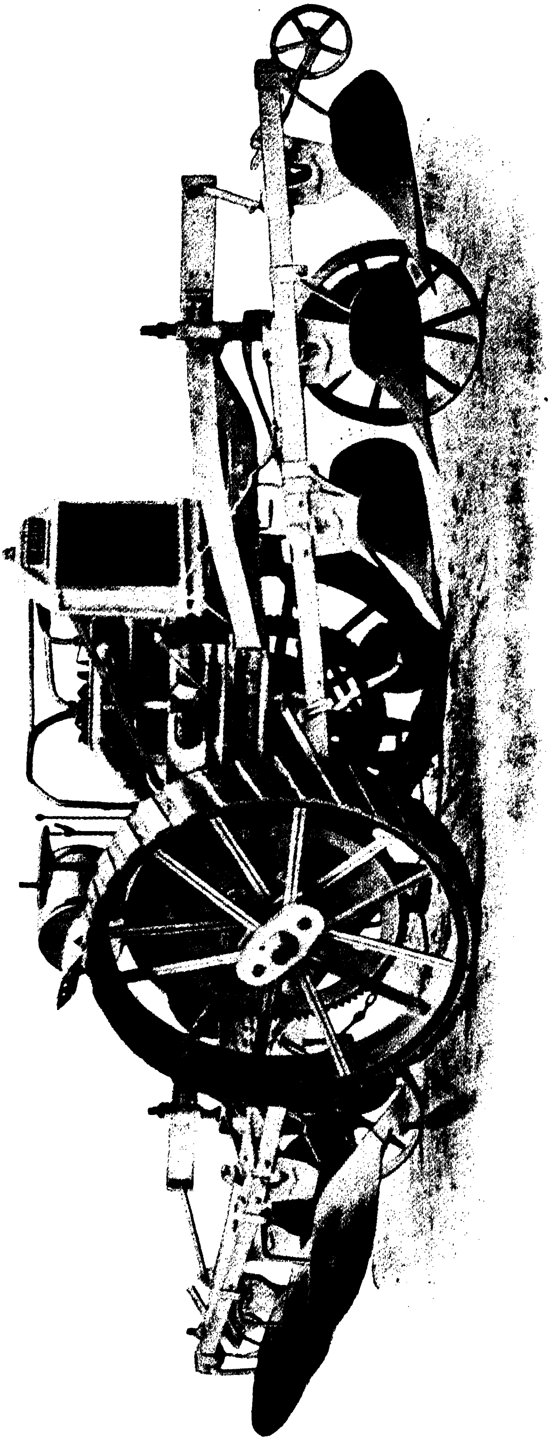
slowly to the outlet at the end of the terrace ", and also the graded terraces, the need for each depending on the ability of the soil to absorb the rain water. The flow of the graded terraces should not be more than 6 inches in 100 feet, and the lengths, according to a table given, should not exceed 1,100 feet on a slope of 15 feet in 100 feet, 1,200 feet on a slope of 10 feet in 100 feet, and 1,500 feet on a slope of 5 feet in 100 feet. Although these terraces are really the portion of the soil cultivated and cannot be considered in anyway similar to our drains in cacao or coconut cultivations, the article is of particular interest, as showing that the principle of letting off the water as slowly as possible is the same as advised in this paper, a feature considered very necessary by the writer of the above one referred to.

Roads, in order to serve their purposes as such, must be graded and cannot retain the water without being damaged and are also expensive when compared with drains. Water pockets are holes one, two or more feet deep, with small trenches leading into them from various directions. These two systems have been tried here and discussed by this society. My objections then held that the road system and graded drains let off the water too quickly before being filtered and also do not ensure complete aeration, and that the water pocket systems, whilst retaining the water and silt, do not distribute the water evenly, do not give sufficient aeration, and are unsafe to labourers when covered with weeds, are still maintained. Roads are indispensable on large estates for transportation purposes and must be kept in proper order ; the cost of their upkeep can be considerably reduced by contour drains on the same field. Water pockets have given good results as may be seen from the following note from the report of Mr. H. Meaden on the Government House Grounds, taken from the Annual Report of the Department of Agriculture of Trinidad and Tobago, for the year 1918, page 27 :— " The citrus plots were clean weeded and ' water pockets ' were opened up ; the trees continue to respond, and the method of water pocketing can now be safely recommended to all planters in the dry hilly districts as a means of conserving moisture for their plants during the dry months of the year."

Contour drains give complete aeration, distribute water evenly and thereby tend to prevent landslips; they furnish soil for mulching, protect roads, effectively check erosion, form ready receivers for leaves, etc., and cacao pods when picked, thereby preventing waste by bursting when rolling down hillsides and extra cost of gathering; they may be used for irrigation purposes when near a natural water course by damming the water and allowing it to flow into an open end of each drain and with care can be used for distributing storm water from roads or waste land, which may concentrate its flow on one particular spot, over large areas of thirsty hillsides.

The valuable results obtained from contour drains on hillsides unfortunately cannot form a table of figures as of experimental data. What has been said of them, coupled with the fact that they are being rapidly extended here, should induce others to give them a little more attention and a thorough trial, which I am sure could only lead to their more extensive use.

PLATE XXIX.



THE TIMESAVER TRACTOR AND ONE-WAY PLOUGH. PLOUGHS RAISED READY FOR TRAVELLING.

TIMESAVER TRACTOR AND ONE-WAY PLOUGH.

THE One-Way Plough possesses well-known advantages for India, more especially for irrigated land. The following description of the "Timesaver," taken from "The Commercial Motor," of March 16, 1920, will probably thus be of interest.

The one-way plough is a device of considerable promise, but until lately little was done with this interesting type of agricultural implement. Why this should be so is somewhat difficult to comprehend, as this machine presents certain advantages over the ordinary type of tractor, if scientifically designed to cope with the same classes of work as can be performed by the latter. It also overcomes certain of the drawbacks which the agriculturist with a knowledge of power ploughing is always ready to criticise in this type.

The advantages which are put forward by the exponents of the one-way plough are: (1) the time lost by turning is greatly reduced; (2) the headlands can be reduced to the narrow width of about four yards; (3) the headlands are not consolidated by the tractor wheels passing constantly over the same ground, thus, incidentally, reducing wear and tear on the machine and saving fuel by reducing the idle running; (4) all the furrows are turned in the same direction, thus eliminating open furrows and high ridges, which sometimes cause damage to harvesting machinery and add to the difficulty of hauling heavy loads of corn during the harvest; (5) the fields can be ploughed throughout without requiring the use of horse-drawn ploughs to strike out and finish the work; (6) when ploughing hilly fields it can work to and fro across a gradient.

The one-way plough has been adversely criticised because in one or two experimental models certain difficulties in steering have been experienced; also these models could not be converted into tractors, and thus could not compete successfully with the ordinary type of tractor.

The engine is a four-cylindered 30 h.p., $4\frac{1}{4}$ in. bore and $5\frac{3}{4}$ in. stroke. Ignition is by high-tension magneto, fitted with an impulse starter. Cooling is by a large gilled radiator of the cast-header and bottom-tank type, assisted by a belt-driven fan. The cooling-water circulation is by centrifugal pump.

The drive from the engine is taken through a dry plate clutch to a gearbox providing two speeds forward and two reverse. The final drive pinion shaft carries two main bevel wheels, either of which can be engaged with a bevel pinion on the gearbox shaft, the drive being forwards or backwards, according to which bevel is engaged. The final drive is by external spur pinions which mesh with large gearwheels bolted to the driving wheels ; in future models all the gears will be totally enclosed and protected from the entry of dirt and water.

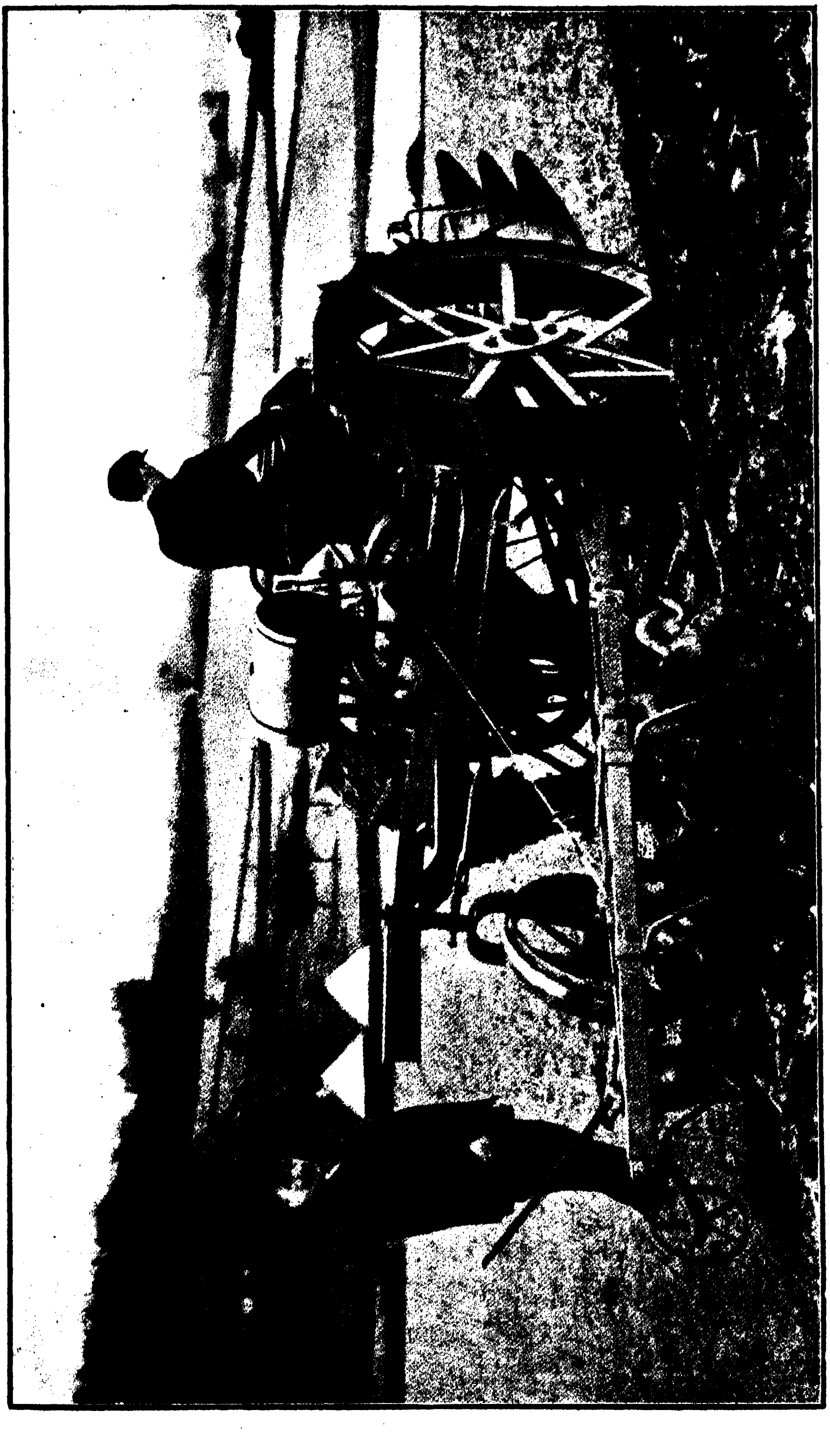
The frame is strongly constructed of rolled channel section steel, suitably braced.

Steering is of the worm and wheel type, the same steering wheel being used for travelling in either direction, and to enable this to be done the driver's seat swivels round the steering column. The pedals and control levers are so situated that they can be operated when the seat is in either direction ; thus duplication of these parts, with its consequent expense and complication, is avoided.

The machine is provided with a three-furrow balanced plough. It incorporates an automatic anti-balance gear by which the forward movement of the tractor pulls the plough into the ground and automatically lifts clear of the ground the idle plough at the opposite end of the frame.

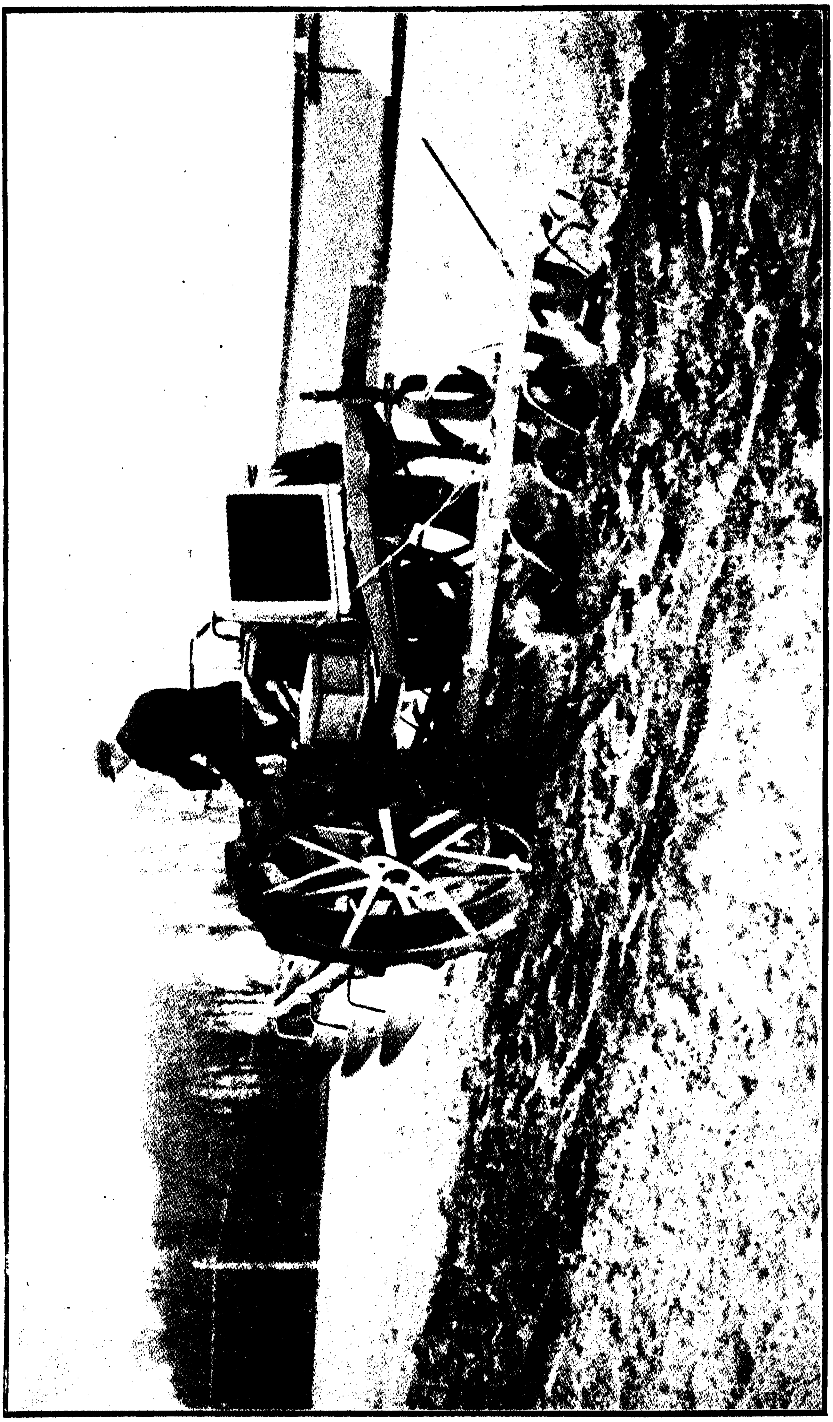
The machine has two large driving wheels at the centre, and a small steering wheel at each end. When it is required to transform the one-way plough into a tractor, the rear steering wheel, with a portion of the frame which supports it, is unbolted and rebolted to the front of the machine. The two steering wheels are then connected together by a tiebar and the frame extensions joined by a cross member, thus making a serviceable tractor. The space above the steering wheels permits of fitting a large box for tools, etc.

PLATE XXX



THE TIMESAVER TRACTOR AND ONE-WAY PLOUGH. PLOUGHING FORWARD.

PLATE XXXI.



THE TIMESAVER TRACTOR AND ONE-WAY PLOUGH: PLOUGHING REVERSE.

No differential is incorporated in the design of the machine. Either wheel can be declutched as desired, thus providing a ready means for turning the whole machine rapidly. The clutches are of the dog type.

The steering wheels are contained in heavy bicycle-type forks and are pressed into contact with the ground by means of spiral springs situated between the supporting brackets and the tops of the forks.

The driving wheels are fitted with spuds $3\frac{1}{2}$ in. deep. The depth of ploughing can be regulated whilst the machine is in operation by means of two hand wheels, which raise or lower the whole plough frame. This is done in a very simple manner by raising or lowering the fulcrum bar supporting the plough frame.

The weight of the present machine is $2\frac{1}{4}$ tons, but it is hoped that this will be reduced to 2 tons in later models.

One of the difficulties with the one-way plough is steering, but in the Timesaver this difficulty has been overcome and the machine is even self-steering. At the end of each furrow one wheel is declutched and the machine swung half round ; it is then reversed until the driving wheel enters the last furrow. The plough is then dropped and the machine carries on. This operation is done so rapidly that practically no time is lost at the headlands.

The Timesaver tractor is capable of ploughing at any speed up to 4 m.p.h., and will plough an acre of land to a moderate depth in one hour without forcing.

At a recent test the machine ploughed one acre to a depth of 8 in. in 1 hr. 10 min., on a fuel consumption of $1\frac{3}{4}$ gallons, the fuel used for the purposes of the test being petrol.

The Timesaver is so designed that all its gears and other details of its mechanism are very accessible and can easily be removed for replacement or repair. The present model does not incorporate a power-pulley, but this will be fitted in future. It will be situated in front of, and parallel to, the near side driving wheel, and will be driven by bevel gears from the front end of the crankshaft.

The Timesaver will be manufactured in two powers—25 h.p. for use with a two to three furrow plough, and 30 h.p. for use with a

three to four furrow plough. In each plough the extra breast will be detachable, so that the tractor will not be strained when ploughing in heavy land.

SPECIFICATION.

Engine. 30 h.p. 4 cylinder internal combustion, $4\frac{1}{4}$ in. bore, $5\frac{3}{4}$ in. stroke. Starts on petrol and will run on paraffin once the engine is warm.

Carburettor. Zenith, single jet, with paraffin vaporising attachment.

Ignition. High tension magneto, with impulse starter.

Cooling. Large gilled tube radiator and belt-driven fan. Water is circulated by means of a gear driven pump. Tractor has ploughed clover lea in summer in a shade temperature of 80 degrees Fah. without overheating.

Transmission. Through dry plate clutch to gear box containing two speeds forward and two reverse, thence through bull pinion to toothed ring on main axle.

Wheels. Driving wheels are 5 ft. in diameter and 10 in. wide. Steering wheels are 2 ft. 6 in. in diameter and 6 in. wide.

Frame. Constructed of rolled channel section steel, securely riveted and bolted together.

Plough. Provided with three-furrow anti-balance plough complete. Plough breast and coulters can be supplied of any particular type to suit customer's requirements.

Power pulley. To drive any class of barn machinery, thresher, or circular saw, etc.; can be fitted, if required, as an extra.

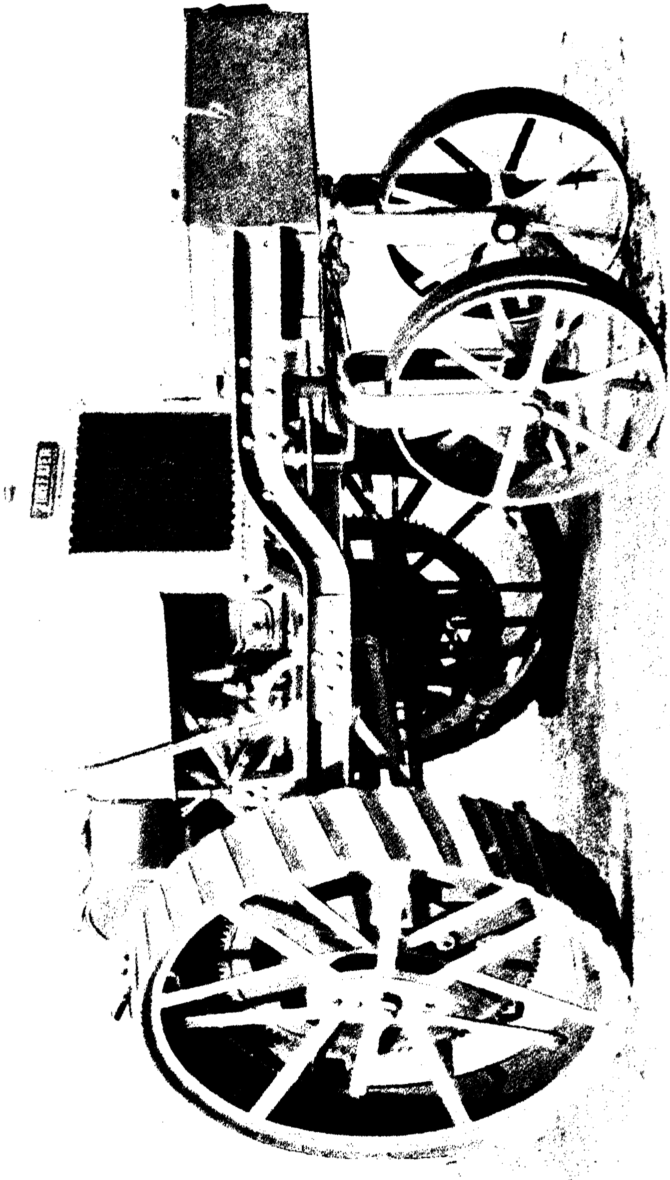
Governor. Patented. Has given excellent results; can be regulated while engine is running and put out of action when ploughing by merely turning a set screw and a lock nut.

Automatic anti-balance gear. Forward movement of tractor pulls plough into ground and automatically suspends idle ploughs at opposite end of frame clear of the ground.

Capacity. Will plough at any speed up to 3 miles an hour.

Weight. Approximate $2\frac{1}{4}$ tons without plough.

PLATE XXXII.



THE TIMESAVER TRACTOR AND ONE-WAY PLOUGH. CONVERTED INTO A GENERAL UTILITY TRACTOR.

Steering. Wheel and worm gearing. Same steering wheel is used for travelling in either direction by revolving driver's seat round the steering column. The machine is self-steering if surface of ground is not too rough.

Notes

UNIFORMITY OF LENGTH OF COTTON HAIRS.

A CONVENIENT method of estimating uniformity of length of lint, which will show the range of variation and also the proportion in which each length is present, does not appear yet to have been published.

The obvious method of measuring a sufficiently large number of single fibres from a representative sample is too tedious to be used as a routine method. The less tedious " available fibre " method described by Harland[1] shows only what percentage, by weight, of the sample is of and above a certain minimum length. It gives no idea of the range of variation nor of the proportion which each length bears to the whole. It assumes that all fibres below the fixed minimum length will be eliminated in the preliminary processes of spinning, which may be true of combed cottons, but is not true of cottons which are not combed. It involves the weighment of small quantities of lint which necessitates great care being taken to avoid error due to changes in the humidity of the atmosphere, and in order to reduce the probable error to a reasonable figure the determination has to be made on ten seeds.

While testing various methods of determining lint length for comparative purposes it was found that Balls' maximum combed length method[2] was strictly applicable to Indian cottons. Incidentally, it was found that it is not necessary to comb out the whole of the lint on the seed. An equally good result was obtained by combing out the lint on the right half of the seed and measuring

[1] *West Ind. Bull.*, Vol. XV, p. 279.

[2] Balls. *The Development and Properties of Raw Cotton*, p. 185.

from the butt end of the median line out to a point on the halo represented by 3 o'clock. It was also found that from the combed length a very good idea of the range of variation of the bulk of the single fibres in the sample could be obtained and also some idea of the percentage of each length present.

In the table shown below, the figures in the columns under I to V are percentages, the left hand column in each case refers to combed length and the right hand column to single fibre length. The actual number of readings made in each case is shown at the foot of the column.

Length in mm.	I *G. n. roseum*		II *G. hirsutum*		III *G. indicum*		IV *G. hirsutum*		V *G. hirsutum*	
11		1								
12		4								
13		4				1				
14	2	5				1				
15	10	15		1		3				
16	21	13		2		2				
17	30	18	1	5	1	4		1		
18	26	12	2	5	3	4		2		
19	8	11	10	8	6	4	1	3		
20	3	7	24	13	22	7	5	4		2
21		4	28	10	24	8	11	9	1	3
22		5	26	11	26	9	20	9	6	2
23		1	8	13	14	14	24	13	15	8
24			1	10	3	15	25	14	25	6
25				9	1	10	11	14	28	13
26		1		4		7	2	11	15	13
27				3		6	1	8	7	15
28				2		2		7	2	13
29				1		1		2	1	10
30				1				2		4
31								1		7
32										2
33										1
34										1
	330	100	212	585	200	300	576	700	419	100

The details for single fibres are :—

I	10	fibres	from each of	10	seeds
II	15	„	„	39	„
III	100	„	„	3	„
IV	100	„	„	7	„
V	10	„	„	10	„

In I and V, the fibres were taken from a tuft drawn from 3 o'clock on the halo.

In II, 10 fibres were from the same part as in I and V and 5 from 1 o'clock on the halo.

In III and IV, 20 fibres were taken from each of 5 points spaced equally round the halo.

The actual order in which the samples were dealt with was IV, III, II, I, V.

Comparing combed length with single fibre length, the minimum figure of the range of the bulk of the single fibres may be taken as the same as the minimum figure of the range for combed length, and the maximum figure as 2 mm. higher, and allowing for the fact that in the ranges of higher value, II to V, the average single fibre length is about 1 mm. higher than the average combed length, the higher frequences in the range of single fibres correspond roughly with the higher frequences of the combed length range.

Part of the routine work which has to be done in breeding cottons is to examine all the progeny plants from a single mother plant for each important character. For lint length this is done by measuring the combed length in 5 seeds from each plant. As there may be as many as 300 progeny plants from one mother plant, it is apparent that by merely tabulating the readings for combed length a very good idea of the range of variation of the bulk of the single fibres, and for all practical purposes, a sufficiently accurate idea of the percentage of each length, can be obtained.

It is unfortunate that the ranges of each of the samples tested are so nearly equal in width. No type with a very narrow range of combed length has, however, yet been discovered. Possibly some other worker on cotton has such a type, on which this result could be tested. [G. R. HILSON.]

WORLD'S COTTON CONFERENCE.

"THE Textile Manufacturer" for June 1921 reproduces in full twenty-four papers read at the World's Cotton Conference held in Manchester and Liverpool from 13th to 22nd June, 1921. All the papers are of more than usual interest. The opening proceedings and social functions at Liverpool and Manchester have been fairly well described in the daily press but, possibly owing to other events of international interest, little attention has been paid to the papers read and these contain much matter of interest to readers of "The Agricultural Journal of India."

The paper by Mr. David R. Coker, the well-known South Carolina seedsman, is of particular interest as it describes the successful solution of a problem which confronts many agricultural departments, *viz.*, the replacement of existing short staple varieties of cotton by longer stapled and more profitable crops. Like many parts of India, South Carolina needs quick-growing cottons; less, however, for climatic reasons, as in our case, than because of the advance of the boll weevil. Success has been obtained by selection from existing mixtures and the foundation has been the plant-breeding work of Dr. Webber who was in charge of plant breeding for the U. S. Department of Agriculture from 1898–1907, more recently Director of the California Experimental Station and now General Manager of Mr. Coker's seed business. Hartsville and much of South California are now growing cotton of 1 3/16″ to 1 3/8″ staple in place of the 7/8″ to 1″ previously grown, and the newer Hartsville strains have proved of great value in the Mississippi Valley. Mr. Coker insists on the absolute necessity of good marketing facilities to establish improved cottons and describes the work which his firm has done to organize the market in its early stages with the co-operation of several far-sighted spinners.

The paper concludes on a note of pessimism and warning. At present prices, cotton growing in America with a standard yield of 250 lb. per acre is barely profitable, and Mr. Coker claims that not only must prices advance but that every possible effort must be made to make cotton growing a more profitable business, both by the improvement of cultural methods combined with the use of the

best strains but also by improved market organization. It was clearly shown in the discussion that followed the paper that under existing circumstances the grower had less than a living wage when cotton fell to 12 cents per lb.

The next paper by Mr. Himbury, General Manager of the British Cotton Growing Association, reviewed the progress made in developing cotton growing within the Empire. He showed that from 1895 to 1918 American consumption had increased from 31 per cent. to 59 per cent. of the American crop, and that the rest of the world was steadily getting shorter of cotton for their various needs. Marked success has been obtained in Nigeria, which produces some 100,000 bales per annum (of which 10,000 bales is cotton of staple above $1\frac{1}{8}''$) and Uganda which produced this season 52,000 bales of cotton of staple from 1 3/16″ to $1\frac{1}{4}$.″ The prospects of the Sudan and of Mesopotamia are discussed, and it is stated that when the Sennar dam on the Blue Nile is complete, another 300,000 acres of cotton may be expected in the Sudan. The assistance given to the West Indies by the British Cotton Growing Association in maintaining and extending Sea Island cotton was also described. The writer puts in a strong plea for the better staffing of the agricultural departments in the colonies and particularly in India. In the following discussion the Director of Agriculture, Baroda State, pointed out the need of further irrigation works to stabilise Indian cotton growing.

Mr. Meadows, of the U. S. Department of Agriculture, introduced the question of universal standards for American cotton and the difference between Liverpool and U. S. A. standards, and a spirited, if somewhat technical, discussion followed.

Mr. A. B. Muir's paper on the "Purchase and Sale of Cotton," with its description of the Liverpool cotton market and lucid explanation of the real value to the spinner and grower alike of a genuine "futures" market, is of particular interest at the present moment as India hopes shortly to have in the East India Cotton Association and its Cotton Exchange in Bombay a sound organization for marketing cotton, the great need of which was pointed out by the Indian Cotton Committee and emphasized by the financial

crisis of 1918. Mr. Muir holds that no movement for spinners to buy direct from growers can ever achieve any real degree of success because future trading is an essential in the present highly organized state of the Lancashire spinning industry. Several papers on the financing of cotton imports followed, including one by Sir J. Hope Simpson, Joint Treasurer of the Conference, but better known in India as one of the earliest organizers of the co-operative societies.

Of the many excellent papers read at the Manchester session, those of most interest to agriculturists are those by Messrs. Howard, Davis, Balls and Crossley.

Mr. Howard's paper on "The Characteristics of Good Spinning Cotton" is an extremely clear statement as to why a spinner is always clamouring that cotton should be even in length, ripe, even in grade and clean. He explains in simple language exactly where defects cause trouble during the spinning process and how comparatively helpless the spinner is if the material is not uniform. He pleaded for better organization all-round which will enable the money now lost through defects to get back to the grower as additional profit.

Dr. Balls' scheme of forecasting the cotton crop by the use of plant development graphs is already familiar to those who read his papers in "The Philosophical Transactions" of 1915 and 1916. He sketches briefly an organization suitable for large cotton tracts and claims that the constant arrival of "forecasts" of the class suggested would do much to check undue fluctuations in price.

Dr. Crossley's paper entitled "Research Work in the Cotton Industry" is of particular interest at the present time. Outlining the intentions of the British Cotton Industry Research Association, he states that in regard to spinning their main object will be to connect the properties of raw cotton with those of the yarn it produces. More accurate methods of testing yarns and cotton are necessary and the designing of instruments of precision for the purpose is an essential preliminary. Many problems in relation to sizing, weaving and finishing await solution, and the aim of the

Research Association will be to try and understand the structural, chemical and physical changes produced during manufacture. We quote one paragraph from the paper as it seems characteristic of the new spirit pervading British industry.

"The application of science to industry is essentially a function of the industry where the closest co-operation is necessary between the research workers and those actually engaged in the industry."

In their report to the conference, the Research and Statistics Committee emphasized the need for a free discussion of the results of scientific research, whether from public or private laboratories, and give as examples of scientific data which could be exchanged, methods of testing fibres, yarns and fabrics, and information with regard to cotton growing. The institution of Cotton Research Associations in all countries represented at the conference was urged and the institution of an International Cotton Research Committee was suggested. The report urged all Government administrations in cotton-growing countries to endeavour to check the mixing of different types of cottons and to maintain purity of type by such methods as controlling supplies of seed, ensuring supplies of pure seed and regulating the transport of cotton-seed and seed-cotton. [B. C. BURT.]

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MANUFACTURE OF SUGAR DIRECT FROM CANE IN INDIA.

IN India there are at present 18 factories making sugar direct from cane. Nine of these are situated in the province of Bihar and Orissa, six in the United Provinces, one in Assam and two in Madras. Enquiries were instituted by the Sugar Bureau to ascertain the quantity of cane crushed, sugar made and molasses turned out by each of these factories during the season 1920-21 extending from the latter half of November to end of April. The Bureau is much indebted to the management of these factories for the readiness with which they supplied the information required.

We give below the total figures of cane crushed, sugar made and molasses turned out by the factories in (1) Bihar, (2) United Provinces, (3) the rest of India, and (4) grand total of all India.

Table showing total production of sugar factories crushing cane, season November 1920 *to April* 1921.

Province	Cane crushed		Sugar made		Molasses obtained	
	1919-20	1920-21	1919-20	1920-21	1919-20	1920-21
	Mds.	Mds.	Mds.	Mds.	Mds.	Mds.
Bihar and Orissa	5,418,264	6,577,083	375,746	465,100	159,251	261,620
United Provinces of Agra and Oudh	2,016,192	2,547,871	133,205	156,777	106,650	119,231
Other Provinces of India	1,617,611	606,461	294,197	47,414	217,795	23,861
Total for India	9,052,067	9,731,415	803,148	669,291	483,696	404,712

It will be seen that 465,100 maunds of sugar are manufactured in Bihar alone. Taking 250 maunds cane as the average yield per acre, it will be seen that, roughly speaking, cane from an area of about 30,000 acres in Bihar is put through factories.

A study of the returns submitted by the factories shows that there is a great margin for improvement in the efficiency of most factories. While one factory required as many as $17\frac{1}{3}$ maunds of cane to make one maund of sugar, another factory made one maund of sugar out of only $11\frac{1}{2}$ maunds of cane. The production of molasses, too, is frequently as high as 50 per cent. of the amount of sugar produced.

It is hoped to collect and publish figures regarding the production of sugar from *gur* or *rab* by modern methods of refining in due course. [WYNNE SAYER.]

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A PRELIMINARY NOTE ON *TRIPHLEPS TANTILUS*, MOTSCH. : AN ENEMY OF THE PINK BOLL-WORM.

IN his paper on the Pink Boll-worm in Egypt (1916-1917) Ballou mentions that *Triphleps* sucks the eggs of the pink

boll-worm. He does not state whether this is *Triphleps tantilus*, but presumably that is the species concerned.

Last year an Anthocorid nymph was seen at Coimbatore, sucking eggs of the pink boll-worm, but as the nymph was subsequently lost it was not recognized as the nymph of *Triphleps tantilus*. This year *Triphleps tantilus* is very abundant and it has now been proved to feed readily on both the eggs and freshly emerged larvæ of the pink boll-worm. The nymphs appear to be even more ferocious in their attacks than the adults. Several cases were seen in the Insectary of a *Triphleps* nymph running about with a pink boll-worm larva impaled on its proboscis.

Triphleps nymphs turned into a tube containing *Platyedra gossypiella* eggs and emerging larvæ fell upon them with avidity, the larvæ being preferred to the eggs.

It is not likely that *Triphleps* gets much opportunity of getting *Platyedra gossypiella* larvæ in the field as they quickly bore into the nearest boll after hatching.

Platyedra gossypiella, however, lays its eggs in places which *Triphleps* chiefly haunts and it seems likely that a fair number are destroyed.

Triphleps tantilus feeds also on cotton Aphis and cotton Thrips and has also been seen, just after feeding on an Aphis, to thrust its proboscis into one of the main veins of a cotton leaf and to remain there for sometime apparently feeding.

The eggs of *Triphleps* are laid at the base of bolls in the rind of young bolls and in leaf stalk. Usually eggs are thrust into whatever part of the cotton plant is chosen, horizontally to the surface, but at other times they may be pushed in vertically.

The nymphs are coloured yellow to yellow orange, with red eyes, and, as already stated, are voracious feeders.

The pink boll-worm is so serious a pest in South India that any addition to the ranks of its enemies is of importance, and it would be interesting to know whether *Triphleps tantilus* has been observed to attack either eggs or larvæ in other parts of India, such as the Punjab where the problem is equally acute. *Triphleps tantilus* is easy to rear and might be used in conjunction with or

instead of the parasites which are at present sent to the Punjab for boll-worm control. [E. BALLARD.] [The boll-worm problem in the Punjab, however, is concerned with *Earias* and not with *Platyedra*.—EDITOR.]

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"SELF-BINDERS" AT KARNAL.

WITH reference to the Note on "Self-binders" in "The Agricultural Journal of India" (Vol. XVI, Pt. 3) by Mr. G. S. Henderson, the Manager of the Dairy Farm at Karnal writes to say that binders have been used at Karnal since 1911. He gives the following particulars:—

We have never used horses for the binders but always bullocks.

For the harvest of 1915 I kept details of cost of cutting with these machines which resulted as follows:—

Cost of cutting with binders, including labour, opening fields and stooking, cost of twine, oil, feed of bullocks, repairs to machines and depreciation.

1. *Oats.* Total cost per acre Rs. 4.

(Quantity of twine per acre 2·8 lb. Cost of twine per acre R. 0-15-0.)

2. *Wheat.* Total cost per acre Rs. 3-8-6.

(Quantity of twine per acre 2·2 lb. Cost of twine per acre R. 0-11-10.)

3. *Barley.* Total cost per acre Rs. 3-8.

(Quantity of twine per acre 3·2 lb. Cost of twine per acre R. 1-9.)

Smaller sheaves were made when cutting barley and consequently more twine was used. The extra cost of twine is accounted for by this being from a later and more costly purchase.

To accomplish the same work by hand we have, in previous and later years, paid from Rs. 5 to Rs. 10 per acre according to the heaviness and condition of the crop, the former figure representing the pre-war cost for cutting an average standing crop, and the latter for a heavy crop, badly lodged, at present rates of wages.

On this showing the use of binders gives a considerable saving, but it must be borne in mind that hand cutters reap a good deal closer to the ground and consequently gather more straw, which, in India, is a consideration. Again, in handling a very ripe or tangled crop, the binders shell out a good bit more grain than hand labour.

The chief advantage of binders on a large farm is that they enable one to harvest large areas at a time when there is a heavy demand for labour and when the labour available would most likely not be able to handle the crop in time.

To work these machines successfully, men with considerable mechanical aptitude are required—a by no means usual accomplishment among Indian labourers. Also, the land at this farm at *rabi* harvest is always exceedingly hard and dry, which, together with irrigation "bunds," cause excessive jolting and continual loosening of nuts.

We have now four 5′ Hornsby Binders, two imported in 1910 and two in 1920. The fact that the 1910 importations are still in use speaks much for their sound construction.

We always use two pairs of bullocks at a time in each machine, and consider we are doing a good day's work when we cut five acres per machine.

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REAPING MACHINES AMONGST WHEAT.

We have received from Lieutenant J. L. Flowerwood, Manager of the Military Farm, Okara, Punjab, an interesting description of work of the reaping machines amongst wheat. The Okara farm is a very large one and 17 reaping machines are now employed. With a sufficient supervising staff, it has been found that the side delivery type is, on the whole, more economical of labour than the manual delivery type. It is also stated that the draught is less in the former case than in the latter. The profit and loss figures for machine cutting, as compared with hand reaping, bear out very closely the results obtained in the canal colonies in 1907-08 (*vide* Article in *Agri. Jour. India,* October 1908) where an average

saving of over Rs. 3 per acre was effected by the use of the reapers. [EDITOR.]

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WATER-HYACINTH COMMITTEE IN BENGAL.

IN pursuance of a resolution relating to ways and means for removing the scourge of the water-hyacinth, passed at the Legislative Council, Bengal, on the 22nd February, 1921, the Local Government, in the Ministry of Agriculture and Public Works, have appointed a Committee composed of the following gentlemen to enquire into the spread of water-hyacinth in Bengal, and to suggest measures for its eradication:—

1. Sir Jagadish Chandra Bose, Kt., C.S.I., C.I.E., F.R.S., D.Sc., *President*.
2. Maharaja Kshaunish Chandra Ray Bahadur, M.L.C.
3. Mr. G. Evans, C.I.E., M.A., Director of Agriculture, Bengal.
4. Rai Sailendra Nath Banerjee Bahadur, Executive Engineer.
5. Dr. Muhammad Ibrahim Sufi, Assistant Director of Public Health.
6. Babu Nibaran Chandra Das Gupta, M.L.C.
7. Khan Bahadur Maulvi Hemayetuddin Ahmad.

The Director of Agriculture will act as Secretary to the Committee.

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HYBRIDIZATION AND EVOLUTION.

IN the "American Naturalist" for June 1920, Professor E. M. East, in an article entitled "Hybridization and Evolution," gives an account of results obtained in the crossing of two species—*Nicotiana rustica* L. and *Nicotiana paniculata* L.

The cross between these two species gives an F_1 generation intermediate between the two parents, and as uniform in each character as either parental group.

Few of the male or the female gametes are viable, yet by careful attention to pollination, from one to twenty seeds can be obtained

in the capsules, where normally two hundred to three hundred seeds are found. These seeds produce an F_2 generation which is inordinately variable. No two plants are similar, and numerous types can be picked out which if found in the wild would undoubtedly be classed as different species. In genetic terms, the behaviour of the two species may be described as follows: They differ in an extremely large number of inherited factors; and owing to these numerous differences, many of the otherwise possible combinations of F_1 gametes are not functional. A huge percentage of expected combinations of both gametes and zygotes are thus eliminated.

The factors which in combination produce normal fertility, recombine in the Mendelian sense, quite as do the factors controlling the form of leaf and flower. The result is that after a few generations of selection one may obtain a variety of strains, uniform within each line, so fertile as to yield capsules with over ninety per cent. of the normal quota of seed, and so different from one another that the extreme types are more unlike than the two original species used in the cross.

After three years of selection (F_5), eight such strains remained out of a large series of selections studied earlier. The smallest type was about 20 cm. in height with small smooth oval leaves, and the largest was nearly 200 cm. in height with wrinkled cordate leaves some of which were 50 cm. in length.

These eight strains were crossed in all possible combinations, and every F_1 generation exhibited as high a degree of fertility as that shown by the parents.

These results are regarded by the author as having an important bearing on certain important problems concerning evolution. The enormous variability of the F_2 generations arising from partially sterile F_1 generations produced by crossing species, lead one, he thinks, to suspect that such combinations might be the basis of a great deal of variability responsible for evolution under domestication. A careful survey of the evidence relating to the origin of modern horses, cattle, sheep, swine, dogs, guinea-pigs, fowls, ducks, and geese on the one hand, and varieties of wheat, corn,

barley, oats, rye, apples, grapes, roses and begonias on the other hand, shows that in every case several related wild or semi-wild species exist which will cross together and yield partially fertile off-spring. Both the historical and the experimental evidence, therefore, point to hybridization, and particularly to species of hybridization, as the great single cause of evolution under domestication.

At the same time, however, the auther says, one must not confuse evolution under domestication with natural evolution. The outstanding biological feature characteristic of the varied groups of domestic animals and of cultivated plants, is the perfect fertility within each group. A marked peculiarity of the great majority of natural species is their sterility with one another, the origin of which has long been a stumbling block to writers on evolutionary biology. His own experimental evidence, as far as it goes, and observations on domestic forms which presumably have originated from combinations of two or more wild species, yield, he thinks, not the slightest indication of tendency toward the production of segregates that exhibit either incompatibility in crosses or sterility of the individuals produced by hybridization. [*Scientific American Monthly*, Vol. III, No. 1.]

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CULTIVATION OF LONG-STAPLE COTTON IN THE SOUTH-WESTERN DISTRICTS OF THE U. S. A.

We are indebted to the Indian Trade Commissioner in London for the following précis of a Report by Mr. C. S. Schofield, of the United States Department of Agriculture:—

Development of the industry. Cotton was first introduced into the irrigated lands of the south-western United States in 1905. Experimental work was carried out from 1905 to 1912 which resulted in the commercial production of cotton of the Egyptian type and of the American Upland type. By 1920 the area under cotton approximated to 500,000 acres. About one-half of this is devoted to American Upland, but there has been no standardization of seed supply for this kind, and now no pure seed of Upland

cotton is available. The other half is under Pima, of which an ample supply of pure planting seed is available.

The industry in this area has temporarily, at least, reached the end of its period of expansion.

The two kinds of cotton. The Upland type includes several varieties which have been hopelessly intermixed with consequent deterioration of quality and yield. The Pima cotton is all of one variety, and special care is taken to maintain purity.

Upland cotton can be grown in 225 days, and is ginned on saw gins, while Pima requires 275–300 days to mature, and is ginned on roller gins. Upland yields about 30 per cent. more lint per acre than Pima, but the yields of seed-cotton are the same. The production costs are about the same, but the harvesting cost of Pima is nearly double that of Upland.

The Upland cotton areas. (1) *Pecos Valley.* The 1920 crop is estimated at 7,000 bales from about 10,000 acres. The pink bollworm appeared in one section of this valley in 1918, but was checked. The Mexican boll weevil has not been reported.

(2) *Rio Grande Valley.* About 22,000 acres under Upland cotton in 1920. Pink boll-worm appeared in two areas in 1920. The area may be reduced this year.

(3) *Yuma Valley.* In 1920 about 15,000 to 18,000 acres were under Upland cotton, and 10,000 under Pima. The Upland crop was unsatisfactory owing to seed admixture. Cotton aphis, cotton stainer and anthracnose have been troublesome : neither pink bollworm nor Mexican boll weevil has yet appeared.

(4) *Imperial Valley.* The area under cotton in 1920 included about 130,000 acres in Mexico and 90,000 in California. Of this area about 28,000 acres were planted with Pima, mostly in California. Cultural methods are poor and only about 10 per cent. of the cotton land has ever been ploughed. Export duties from Mexico are high. In California there is no systematic rotation of crops, and there is a shortage of water nearly every year. The situation is not satisfactory, and the acreage will probably be reduced.

(5) *Coachella Valley.* Only about 1,000–1,500 acres were under Upland in 1920 and a few hundred acres under Pima. Some

small experimental plots gave very high yields of Upland (as high as 3,300 lb. of seed-cotton per acre). Possibly attempts may be made here to establish a pure strain of Upland for seed distribution.

(6) *San Joaquin Valley.* In 1920 there were about 20,000 acres of cotton, half Pima and half Upland. Most of the cotton is grown with pumped water : in the higher lands the lift is over 100 feet and Upland cannot profitably be grown. The outstanding feature is the fruitfulness of both varieties in this valley ; boll shedding is much less than in the South and East.

Pima cotton. Prior to 1920 Pima cotton was extensively produced only in the Salt River Valley, Arizona, where it was first grown in 1912. At first the Yuma variety was grown and Pima was developed by selection from this. The purity of this variety is now carefully maintained by separate ginning and by field inspection. At present there are about 180,000 acres of Pima in the valley alone, ana altogether about 240,000 acres from which a crop of 120,000 bales is expected.

Gins and ginning. In the south-western districts there are 548 gins, 390 of which are in Salt River Valley. In that valley at the height of the harvest the picking reached 1,000 tons of seed-cotton daily, or 1,000 bales of lint, whereas the daily ginning capacity was only 700 bales. The charge for ginning Pima in 1920 was $1·20 per 100 lb. of seed-cotton, together with $4·00 a bale for the support of the organization that imports the pickers. Mechanical feeders are in general use. Some new departures have been made in the coverings of the rollers. A heavy hydraulic packing made of rubber and cotton has been substituted for leather.

The Upland crop is ginned on saw gins at a cost of about 35 cents per 100 lb. of seed-cotton plus $2·25 per bale for bagging and ties.

Pima has not been compressed at primary shipping points, being sent to the mills in low-density bales. The Upland crop is, however, mostly compressed before shipment.

Seed crushing. There are a number of oil mills in the South-west. Before the war the mills paid $15·00 a ton for seed ; during

the war this advanced to $85 to $100 a ton, but has since fallen back to the pre-war price.

Labour situation. At first the Indians of the Arizona reservations supplied the pickers, but as the acreage extended, this source of supply was inadequate. Mexican labour was, therefore, imported. To raise the necessary money all the ginneries were persuaded to agree to increase the ginning charge by $2·00 a bale and pay over to the labour organization the money so collected as a fund for securing pickers. On the security of these agreements the banks advanced the funds required to the labour organization. This scheme has worked well. At first the rate of pay for picking Pima was $2·00 per 100 lb. of seed-cotton (1916); the rate has been increased from time to time until in 1920 the pickers were paid $4·00 per 100 lb. In 1920 there were about 30,000 pickers in the Salt River Valley. Attempts to introduce a similar system in the Yuma and Imperial Valleys have not been successful, because the ginners would not all agree to assess their customers. In the Imperial Valley there has been no shortage of labour in Mexico, where Chinese, Japanese and Mexican labour is employed, but north of the frontier there is perpetual shortage.

On the average pickers gather 60 to 100 lb. of seed-cotton a day in Pima fields, and 125 to 175 lb. a day when picking Upland cotton. Taking as an average yield 1,000 lb. of seed-cotton per acre from Pima, provision must be made for 1 picker for 6 acres. For Upland cotton 1 picker for 12 acres will suffice.

Cost of production. Estimates were prepared in 1913 and 1914 by the U. S. Department of Agriculture. By adding the fixed charges, growing cost and net harvesting cost, and deducting the sum derived from sale of seed, the estimated cost per lb. of lint varied between 16·4 cents and 12·3 cents, according as to whether the yield was taken as 1,200 lb. of seed-cotton or 2,552 lb. of seed-cotton per acre. It was estimated that the lint would fetch 20–22 cents per lb.

For 1920 the yield was considerably less, and the estimated cost per lb. of lint varies between 60·4 cents and 40·6 cents according as to

whether the yield is taken as 800 lb. of seed-cotton or 1,600 lb. of seed-cotton per acre.

From an analysis of the cost of production and the relative prices obtainable for the lint, the conclusion is drawn that there is no ground for changing from Pima production to Upland cotton, and emphasis is laid on the importance of securing large yields by careful selection of land and sound methods of cultivation.

Climatic difficulties. The crop in the South-west is subject to the hazards of climate no less than in the Eastern belt, and in the San Joaquin Valley in particular boll-opening is sometimes delayed in the lower fields after the first frost by the excessive humidity of the air.

Boll shedding. This is a very serious factor in reducing yields in the South-west, and a means of minimizing must be found so as to get larger yields, if profitable crops are to be grown under present economic conditions. Climatic conditions are probably primarily responsible, but the effect can be minimized by proper cultural differences.

The best cultural practice has not, however, yet been determined. It is probable that the remedy will be found in adapting the amount of irrigation to the permeability of the different soils, and ascertaining by experiment the most favourable time for irrigating the plants.

Cotton production and other crop industries. Cotton crops always decline in yield if grown on the same land in several successive years, but in the South-west it was found difficult to devise a profitable crop rotation. Alfalfa, grain and truck crops were suggested, but the livestock locally was insufficient to consume them, and they are too bulky to be worth long shipment. If the yield of cotton is to be increased this difficulty must be overcome.

Large-scale cotton production. The following general principles are stated :—

1. The average cotton farm is not very profitable and the large enterprise must get better than average yields at little, if any, more than average production costs if it is to return a profit on the investment.

2. Expensive overhead costs must be avoided and labour must be continuously and effectively employed.

3. Cotton must be grown in rotation with other crops if yields are to be maintained and labour and equipment effectively utilized.

4. The other crops grown in connection with cotton for purposes of rotation must be so produced and utilized as to return at least a small profit on their own account, and not stand as a liability against the cotton crop.

5. The whole operation should be so conceived and conducted as to pay a reasonable return on the investment over a period of years, and not so as to have to look for ultimate profit to an increase in land values.

Seed supply. Pima seed is ginned separately, and one gin is needed solely for seed-cotton from selected fields intended to supply seed for planting. Adequate supervision and field inspection are ensured by the Tempe Cotton Exchange.

Upland seed is now hopelessly mixed, and the introduction of new supplies is debarred by fear of the danger of insect invasion. The effect of the seed mixture has been deterioration in both yield and quality. The only remedy is to be found in the production locally of better planting seed.

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EMPIRE COTTON GROWING.

THE LEVY ON RAW COTTON IN UNITED KINGDOM. The Empire Cotton Growing Committee announce that the assent of the owners of more than 90 per cent. of the spinning spindles in the United Kingdom has now been obtained to the proposed levy of *6d.* per bale of 500 lb. on all raw cotton used in the country, the proceeds of which levy are to be devoted to the purposes of the Empire Cotton Growing Corporation. The Committee are gratified that so high a degree of unanimity has been reached with regard to this proposal, and the successful completion of the levy has been reported to the Liverpool and Manchester Cotton Associations, who have undertaken to consider the methods that should be adopted to

enable the Associations to collect the amount represented by the levy on imported cotton. When the Associations have reached a decision on this point, steps will at once be taken to apply through the President of the Board of Trade for the grant of the Charter under which it is intended to establish the Corporation. [*The Board of Trade Journal*, dated 2nd June, 1921.]

GRANT FROM EGYPTIAN SURPLUS. It has been decided by the Government to allot the British share in the Egyptian Cotton Surplus—up to a maximum of one million sterling—to the Board of Trade for the development of cotton growing within the Empire. It is the intention of the Board to devote this surplus as a capital sum to the purposes of the Empire Cotton Growing Corporation.

The Government had previously undertaken to provide £50,000 a year for five years to the Corporation under the condition, which has been fulfilled, that the owners of at least 90 per cent. of the cotton spindles in the country should agree to a levy at the rate of 6*d.* a bale on the raw cotton consumed here. The allotment of the above capital sum will be in lieu of this Government grant and will be subject to the continuance of the financial co-operation of the cotton industry. [*The Board of Trade Journal*, dated 9th June, 1921.]

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RESTRICTIONS ON IMPORT OF SUGARCANE.

IN exercise of the powers conferred by sub-section (1) of section 3 of the Destructive Insects and Pests Act, 1914 (II of 1914), the Governor-General in Council is pleased to direct that the following further amendment shall be made in the order published with the notification of the Government of India in the Department of Revenue and Agriculture, No. 13-C, dated the 7th November, 1917, namely :—

For paragraph 6 of the said order the following shall be substituted, namely :—

" 6(i) Sugarcane shall not be imported into British India by sea from the Fiji Islands, New Guinea, Australia or the Philippine Islands.

"(ii) Sugarcane shall not be imported into British India by sea from any other country unless it is accompanied by an official certificate that it has been examined and found free from cane borers, scale insects, aleurodes, root disease (any form), pine apple disease (*Thielaviopsis ethaceticus*), *sereh* and cane gummosis, that it was obtained from a crop which was free from Mosaic disease and that the Fiji disease of sugarcane does not occur in the country of export.

"Provided that in the case of canes for planting imported direct by the Government Sugarcane Expert and intended to be grown under his personal supervision, such certificate shall be required only in respect of the freedom of the country of export from the Fiji disease of sugarcane."

PERSONAL NOTES, APPOINTMENTS AND TRANSFERS, MEETINGS AND CONFERENCES, ETC.

We deeply regret to have to record the death of Mr. G. A. D. Stuart, I.C.S., Director of Agriculture, Madras, which took place in Madras on the morning of Monday, the 8th August, 1921.

The late Mr. Stuart was one of the most successful Directors of Agriculture. He officiated in 1919 for six months as Agricultural Adviser to the Government of India and Editor of this Journal.

MR. F. J. WARTH, M.Sc., late Agricultural Chemist, Burma, and Offg. Imperial Agricultural Chemist, is appointed Physiological Chemist, Agricultural Research Institute, Pusa, with effect from the 1st July, 1921. Mr. Warth will, in addition to his duties as Physiological Chemist, continue to officiate as Imperial Agricultural Chemist until further orders.

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MR. G. R. HILSON, B.Sc., has been appointed to officiate as Director of Agriculture, Madras.

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MR. F. R. PARNELL, B.A., Government Economic Botanist, Madras, has been appointed to take over, in addition to his own duties, the office of Principal of the Agricultural College, Coimbatore.

MR. H. T. ASHPLANT has been appointed Second Mycologist, Madras, for the investigation of diseases affecting rubber.

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* *

MESSRS. D. ANANDA RAO, M. R. Ramaswami Sivan and T. S. Venkatraman, of the Madras Department of Agriculture, have been promoted to the Indian Agricultural Service, and appointed Deputy Director of Agriculture, Lecturing Chemist, and Government Sugarcane Expert, respectively, in that department.

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* *

MR. J. H. G. JERROM, M.R.C.V.S., who has been appointed to the Indian Civil Veterinary Department and posted to the Bombay Presidency, has been appointed Superintendent, Civil Veterinary Department, Sind. He has also been placed in charge of the Civil Veterinary Department in Baluchistan and Rajputana in addition to his own duties.

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MR. M. M. MACKENZIE, Superintendent of the Sepaya Farm in Bihar and Orissa, has been granted privilege leave for two months from the 6th August, 1921.

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DR. THAKUR MAHADEO SINGH, Offg. Agricultural Chemist to Government, United Provinces, has been granted combined leave for six months, Lala Har Narain Batham officiating.

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MR. O. T. FAULKNER, B.A., Offg. Professor of Agriculture, Lyallpur, has been granted combined leave for six and a half months or for such short period as may elapse before his transfer to service under the Government of Nigeria.

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MR. H. R. STEWART, Deputy Director of Agriculture under training at Lyallpur, is appointed to officiate as Professor of Agriculture, *vice* Mr. O. T. Faulkner.

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MR. T. F. QUIRKE, M.R.C.V.S., has been confirmed in the appointment of Chief Superintendent, Civil Veterinary Department, Punjab.

Lieut.-Colonel G. K. Walker, C.I.E., O.B.E., Principal, Punjab Veterinary College, Lahore, is granted privilege leave for three weeks, Captain E. Sewell officiating.

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Mr. W. Taylor, M.R.C.V.S., Professor of Pathology and Parasitology, Punjab Veterinary College, Lahore, has been granted 23 days' furlough on full average salary, Captain K. J. S. Dowland holding charge in addition to his own duties.

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Captain E. Sewell resumed charge of his duties as Post-graduate Professor, Punjab Veterinary College, Lahore, on the 23rd May, 1921, relieving Mr. W. Taylor, M.R.C.V.S., Professor of Pathology and Parasitology, of the additional duties of Post-graduate Professor.

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Mr. D. Hendry, B.Sc., Deputy Director of Agriculture, Burma, is transferred from Mandalay and posted to the charge of the Southern Circle, with headquarters at Insein, *vice* Mr. R. A. Beale, who reverts to his substantive appointment as Assistant Botanist.

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The University of Edinburgh has conferred the degree of D.Sc. (Agriculture) upon Mr. D. Clouston, C.I.E., Director of Agriculture, Central Provinces.

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The Government of India have decided to add a representative of the Indian Merchants' Chamber and Bureau, Bombay, to the list of non-official members of the Central Cotton Committee published in paragraph 4 of their Resolution No. 404-22, dated the 31st March, 1921, which was reproduced in this Journal (Vol. XVI, Part 3, May 1921).

Reviews

Chemical Fertilizers and Parasiticides.—By S. HOARE COLLINS, M.Sc., F.I.C. Pp. xii+273. (London: Baillière, Tindall & Cox.)

THIS is a companion volume to the work by the same author, "Plant Products and Chemical Fertilizers," which has already been reviewed in this Journal (Vol. XIV, p. 364). In the previous work chemical fertilizers were dealt with only briefly and from the point of view merely of crop increment, but in the present volume the sources and methods of manufacture take precedence and are treated in considerable detail.

The work is well written and arranged, is very readable and contains much useful information as to the latest developments: for example, the manufacture of potash salts from blast furnace dust, the utilization of atmospheric nitrogen in the manufacture of fertilizers, and particularly such processes as those of Cottrell for dust recovery. These have been developed particularly in the United States where, for example, the Anaconda Copper Mining Company of Montana make use of over 100 miles of chains suspended between plates and electrically charged to precipitate flue dust.

The work is not too severely technical and will undoubtedly be of great service to the general reader who wishes to become acquainted with the principles of the valuation of fertilizers, the distribution of fertilizers over rotations of crops, the nature of manures for special soils and climates and for special crops. These subjects are treated in special chapters. The results obtained at

Cockle Park in Northumberland should be of particular interest to Indian readers as showing the extraordinary effect of phosphates in promoting root development where such is lacking and in modifying the texture completely and changing the character of poor soils. In grass lands the tendency is to develop a thick mass of useless grass which keeps rain from penetrating into the lower soil so that root development is very feeble. On the other hand, by using phosphates the roots break up the soil, and convert an indifferent clay into a fair loam. Accompanying this is a complete change in the bacterial decomposition of the organic matter in the soil accompanied by a great enrichment of the soil nitrogen. Thus on the Tree Field at Cockle Park eleven years' treatment with slag and superphosphate has increased the nitrogen in the soil from 0·185 to 0·236 per cent., that is, an addition of 850 lb. of nitrogen per acre. This stands in marked contrast with the use of nitrogenous manures such as sulphate of ammonia and nitrate of soda, with which practically no increase of nitrogen occurs. The great improvement in quality of the hay and pasture which accompanied treatment with basic slag or super is emphasized. This has enabled a much larger stock to be kept with considerably less expenditure on concentrated feeding stuffs. The better feeding value of the hay has reduced the amount of cake needed in the winter months. The improvement, as was also found at Rothamsted, is due largely to the increase in the proportion of leguminous plants such as clover, for a good growth of which the phosphate supply is all important. The application of basic slag at Cockle Park not merely gave a greatly increased yield of hay and mutton grazed on the fields, but quadrupled the amount of phosphoric acid consumed per acre by the animals. The question of quality of crops as distinct from mere yield is one which in India is of extraordinary importance, but has as yet practically remained untouched. In this connection the author emphasizes that the most nutritious pastures in England and the best dairy pastures in France are those richest in phosphates, whilst the best wines of France are those which contain the greatest quantity of phosphoric acid. [W. A. D.]

Two New Books on Scale-Insects.—(1) LEONARDI, G. Monografia della Cocciniglie italiane. Portici; pp. vii+555, 375 figs. March 1921. (2) MACGILLIVRAY, A. D. The Coccidæ Illinois; pp. viii+502; Jan. 1921; Price $6 nett.

THE first of these two books is a posthumous work produced under the editorship of Professor Silvestri and illustrated with the numerous and excellent figures which we associate with the publications of the Portici Laboratory. Although essentially a monograph of the Italian Coccidæ, many widely-distributed species, occurring in the Indian region also, are described and figured.

The second book contains tables for the identification of the subfamilies and some of the more important genera and species together with discussions of their anatomy and lifehistory, and has been developed from notes originally collected for the use of students in the identification of Coccids. The omission of any explanatory figures or diagrams is in great contrast to the wealth of illustration in Dr. Leonardi's monograph; the author states that the tables were prepared for the use of students, that those who have had experience in teaching know that most students will not undertake anything they are not forced to do, and that the omission of figures makes it necessary for them to study their specimens rather than figures; but, whilst such an argument applies to the notes for students in their original form, we think that it scarcely applies to a book such as is now issued to a wider circle and that the inclusion of at least a few figures will undoubtedly improve any further editions. It is impossible to give an abstract of a book of this nature, which is itself largely a summary, but we must disagree with the author's statement (p. 69) that the female of *Monophlebus* is unknown, a statement repeated on p. 71, where *M. stebbingi* is omitted from the East Indian species mentioned. Many new generic names are introduced and it would have assisted systematic workers if these had been more clearly marked as *genera nova* or if a list of new terms had been added at the end of the book; as it is, one has to dig them out from the closely-printed tables; we find, for example, that the Indian Coccid, *Aspidiotus artocarpi*, Green, is made the type of a new genus, *Partargionia*, characterized on

page 394 and described more fully on page 458, where *artocarpi* is given as the sole species; but it is necessary to wade through the whole of the tables to discover what new genera have been introduced as regards the Indian fauna.

Both of these books will be indispensable to all workers on Indian Coccidæ. [T. B. F.]

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Birds of an Indian Village.—By D. DEWAR. Pages 146, coloured frontispiece and 44 text-figures. (Oxford University Press.) Price Rs. 2-8.

IN this little book the author has written fifty short chapters on Common Indian Birds. The accounts of the various birds are written in simple language, supposedly addressed to an Indian villager, but they contain a large amount of information and may be commended to all interested in the study of bird-life. Some of the illustrations are rather crude (*e.g.*, that of the Common Mynah on p. 35), but there is little difficulty in recognizing most of the portraits given here. [T. B. F.]

Correspondence

A CURIOUS DISEASE AMONGST POULTRY.

To The Editor,

The Agricultural Journal of India.

Sir,

With reference to the note on page 453 of this Journal for July 1921, on the above subject, it is suggested that there is a considerable resemblance with " tick paralysis " in certain animals in Australia. Experiments there are recorded in " The Agricultural Gazette of New South Wales " for May 1921. The particular resemblance lies in the fact that emulsions of the spinal chord, etc., injected subcutaneously into healthy fowls fail to convey the disease. Similarly in tick paralysis it was found impossible to reproduce the disease by inoculation from the diseased subject, and the inference is that the paralysis was set up not by any organism introduced by the tick, but by a toxin injected by the tick into the host.

Yours faithfully,

18*th* *July*, 1921. J. Matson.

NEW BOOKS

ON AGRICULTURE AND ALLIED SUBJECTS

1. THE Diseases and Pests of the Rubber Tree, by T. Petch. Pp. x+278+vi plates. (London: Macmillan & Co.) Price, 20*s*. net.
2. How to Teach Agriculture: A Book of Methods in this Subject, by Prof. Ashley V. Storm and Dr. Kary C. Davis. Pp. vii+434. (London: J. B. Lippincott Co.) Price, 12*s*. 6*d*. net.
3. Insects and Human Welfare, by Prof. Charles T. Brues. Pp. xii+104. (London: Oxford University Press.) Price, 10*s*. 6*d*. net.
4. Dairy Bacteriology, by Prof. Orla-Jensen. Translated from the second Danish edition by P. S. Arup. Pp. xii+180. (London: J. and A. Churchill.) Price, 18*s*. net.
5. Veterinary Hygiene, by R. G. Linton. Pp. 443. (London, W. Green.) Price, 26*s*.
6. The Coconut, by E. B. Copeland. Second edition, revised. Pp. 241. (London: Macmillan & Co.) Price, 20*s*.

The following publications have been issued by the Imperial Department of Agriculture in India since our last issue:—

Memoirs.

1. New Indian Gall Midges (Itonididæ), by E. P. Felt; Three New Wasps from India, by G. R. Dutt, B.A. (Entomological Series, Vol. VII, Nos. 4 and 5.) Price, As. 12 or 1*s*.
2. Die-back of Chillies (*Capsicum* spp.) in Bihar by Jehangir Fardunji Dastur, M.Sc. (Botanical Series, Vol. XI, No. 5.) Price, R. 1 or 1*s*. 4*d*.

Bulletins.

3. A Summary of Experiments on Rice in Bihar and Orissa from 1912 to 1919, by G. C. Sherrard, B.A. (Bulletin No. 96.) Price, As. 10.
4. Cotton Bollworms in India, by T. Bainbrigge Fletcher, R.N., F.L.S., F.E.S., F.Z.S., and C. S. Misra, B.A. (Bulletin No. 105.) Price, As. 8.
5. Experiments in Egypt on the Survival of the Pink Bollworms (resting stage larvæ) in ripe damaged Cotton Bolls buried at different depths, by F. C. Willcocks. (Bulletin No. 107.) Price, As. 5.
6. The Preservation of Wood against Termites, by T. Bainbrigge Fletcher, R.N., F.L.S., F.E.S., F.Z.S., and C. C. Ghosh, B.A. (Bulletin No. 110.) Price, As. 3.
7. The Preparation and Reproduction of Scientific Illustrations, by A. W. Slater. (Bulletin No. 114.) Price, As. 4.
8. The Saving of Irrigation Water in Wheat Growing, by Albert Howard, C.I.E., M.A., and Gabrielle L. C. Howard, M.A. (Bulletin No. 118.) Price, As. 4.

Indigo Publications.

9. The Nature of the Changes occurring during the Extraction of Indigo from the Java Plant (*Indigofera arrecta*), by W. A. Davis, B.Sc., A.C.G.I. (Indigo Publication No. 9.) Price, R. 1.
10. Note on the Deterioration of Indigo Seed during Storing, by Major W. R. G. Atkins, Sc.D., F.I.C. (Indigo Publication No. 10.) Price, As. 3

Report.

11. Proceedings of the Third Meeting of Mycological Workers in India, held at Pusa on the 7th February, 1921, and following days. Price, As. 11.

THE INDIAN WHITE-EYE (*ZOSTEROPS PALPEBROSA.*)

Original Articles

SOME COMMON INDIAN BIRDS.

No. 12. THE INDIAN WHITE-EYE (*ZOSTEROPS PALPEBROSA*).

BY

T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S.,
Imperial Entomologist;

AND

C. M. INGLIS, M.B.O.U., F.E.S., F.Z.S.

ALL of the birds with which we have dealt in our previous papers have been not only common, but also conspicuous species, probably well-known to all who live in India. The subject of our present note, however, although sufficiently common in all localities in the Plains, is decidedly not a conspicuous bird and is easily passed over unnoticed.

The White-eye is a small bird, two-thirds only of the size of the common sparrow, in colour greenish-golden yellow, greyish-white below, with a bright yellow chin and throat and a patch of yellow beneath the tail; around the eye is a ring of white feathers, whence this bird derives its popular English name; on this account it is also sometimes called the Spectacle Bird. It seems to have no vernacular Indian name. This white eye-ring is distinctive and readily permits the identification of its owner as a member of this group, which was classed in the *Fauna* volume on Birds in a sub-family connecting the Babblers and the Thrushes but which is now placed as a separate family, the Zosteropidæ. Five forms of White-eye

are recognized in the *Fauna* volume on Birds, but it seems probable that some of these are merely geographical races of the common Indian species.

All the White-eyes are small birds, which go about in flocks, frequenting trees and bushes, whose leaves they search for small insects, varying their food at times with small buds, seeds and fruits. Like most other birds which associate in small parties, they keep up a constant call one to another, their call being best described as a cheeping twitter.

The food of the White-eye consists of a mixed diet of insects and vegetable matter. Of sixteen birds examined at Pusa by the late C. W. Mason, eleven contained small buds, seeds and wild fig fruits, and five contained insect food, consisting mostly of weevils and ants. One bird, examined by Mr. d'Abreu at Nagpur, had been feeding on berries of *Zizyphus œnoplia.* The White-eye has also been recorded as damaging ripe mangoes and guavas, and will eat plantains when in captivity. In spite of a decided taste for ripe fruit, however, this bird cannot be called a pest of fruit-trees and probably does a considerable amount of good by picking off small insects throughout the year.

The White-eye occurs throughout the whole of India, both in the Plains and in the Hills, in Ceylon and the Nicobars, and in Upper Burma. It breeds, according to locality, from January to September, but the beginning of the hot weather is its normal breeding season in most localities, and at that time the cock bird sings a sweet little song. In North Bihar it breeds from April to July, the earliest nest having been found on 1st April and the latest on 23rd July. With the exception of one nest found in a jak tree, all the nests found have been in mango trees. Sometimes there are two broods in the year. The nest is suspended between two twigs or more rarely in a fork of a branch, at any elevation from less than a foot to sixty feet from the ground, but the majority build at comparatively low elevations, between two and six feet from the ground. It varies much in size and in the materials of which it is composed but is always a soft, delicate little cup, sometimes quite shallow, sometimes decidedly deep, and almost always is

suspended like a miniature Oriole's nest, from small twigs or leaves. The parent birds set to work with cobwebs and first tie together two or three leafy twigs, to which they intend to attach their nest, and then use any available fine fibrous material (such as vegetable fibres, fine roots, thread, floss silk or cobwebs) to complete the outer fabric of their very beautiful and compact nest. As the work progresses, more fibres and cobwebs are used, so that the nest might be taken by a casual observer for an accidental accumulation of rubbish caught in a spiders-web. The interior is lined with silky seed-down, hair, feathers, moss, fine grass, etc., according to the materials available. The external diameter of the nest is about $2\frac{1}{2}$ to 3 inches and the depth varies from one to two inches, the egg-cavity being about $1\frac{1}{2}$ inches in diameter. Two eggs are laid as a rule, occasionally three and very rarely four. The egg is rather long and pointed at the smaller end, about 16 mm. long by 12 mm. broad, in colour uniformly very pale blue or greenish blue, without any markings ; but occasionally the egg is capped with a zone of rather deeper and purer blue.

Our Plate gives an excellent idea of this bird and of its nest as built in the fork of a branch of a mango tree.

An interesting account of the feeding of the young is given by B. B. Osmaston, who says that he observed one of the parent birds place rather a large insect into the wide open mouth of one of the young which in spite of many efforts appeared to be unable to swallow it ; the other parent, which was watching operations from above, seemed to grasp the situation at once, for he (or she) bent down and put a small drop of liquid into the widely gaping mouth ; the process of giving small drops of liquid was repeated in front of the observer quite four or five times, and he was so close that there could be no mistake ; eventually the insect became soft and more manageable and the little bird's efforts were crowned with success.

The Indian White-eye is commonly seen in the Calcutta bird market at Tiretta Bazaar and is easily kept in confinement on a diet of bread and milk, soft fruit and small insects, and is well worth keeping.

OBSERVATIONS ON THE WILT DISEASE OF COTTON IN THE CENTRAL PROVINCES.*

BY

S. L. AJREKAR, B.A.,

Plant Pathologist to the Government of Bombay;

(Formerly Mycologist to the Government of Central Provinces)

AND

D. V. BAL, L. AG.,

Bacteriological Assistant, Department of Agriculture, Central Provinces.

CULTIVATORS of cotton in the Central Provinces are accustomed to find a larger or smaller number of plants withering untimely in their cotton fields every year. As the conditions of soil and weather are otherwise favourable for the growth of the cotton plant, this untimely death of some plants is rightly suspected to be due to some disease, and the prominent symptom of drooping of leaves associated with it gives it the name " wilt."

This withering of cotton plants may be due to two distinct causes : an insect (stem-borer, *Sphenoptera gossypii*) and a fungus. The insect-caused wilt is easily distinguished from the fungus-caused one by the ease with which the insect-attacked plants can be pulled up and also by the swelling at the root and tunnels which the insect produces. The fungus-caused wilt, on the other hand, is distinguished by a blackish or brownish discoloration of the woody tissues which is easily visible on peeling off the bark of the root. There is no swelling on the tap-root, which is also otherwise intact.

* Paper read at the Eighth Indian Science Congress, Calcutta, 1921.

The withering in the case of the insect attack, again, is sudden and occurs over the whole plant at once. In the case of the fungus attack, the wilting is usually, though not invariably, gradual, spreading over the different parts of the plant one after another.

The fungus-caused wilt alone will be considered in this paper.

THE DAMAGE DUE TO COTTON WILT.

Estimates of the damage due to the fungus-caused wilt are likely to be exaggerated owing to the possibility of borer-attacked plants being counted among "wilted" plants in the field. On the Nagpur Agricultural College Farm this year (1920), for example, among several hundred plants uprooted as "wilted" plants, the great majority proved on closer examination to be attacked by the borer. Even allowing for this possibility of exaggeration, there is reason to believe that the damage due to the fungus-caused wilt is appreciable, especially in the Berars, and is on the increase, as would be seen from the following estimates made from time to time by officers of the Central Provinces Department of Agriculture :—

Year	Locality	Estimated damage from wilt	Remarks
1907[1]	Saoner tract, Nagpur District.	Nearly 5 per cent.	
1908[2]	Akola	30 per cent. over an area of 80 acres	
1911-12[3]	Yeotmal District	33 ,,	Average of 5 villages.
,,	Amraoti ,,	25 ,,	,, ,, 4 ,,
,,	Akola ,,	18 ,,	,, ,, 3 ,,
,,	Buldana ,,	10 ,,	,, ,, 1 village only.
1919	Ellichpur ,,	47 ,, in *roseum* and *gaorani* cottons	Estimates made by the Agricultural Assistant, Akola, and figures kindly supplied by the Deputy Director of Agriculture, Western Circle.
	Kandly	15 ,, in *bishnoor* type	

[1] Evans, G. *Agri. Jour. India*, vol. III, pp. 78–80, 1908.

[2] Butler, E. J. *Mem. Dept. Agri. India*, vol. II, no. 9, p. 20.

[3] Clouston, D. *Rep. Agri. Stat. Akola*, 1911-12, Appendix C. These records are particularly reliable, the method followed being to count the number of diseased plants in a 100 and uprooting and submitting them for microscopic examination to the Imperial Mycologist.

Cultivators also recognize that the disease is on the increase, and many of them state that they can remember the spots in their fields where they observed the disease for the first time and from which they have noticed it to spread to other parts of the fields in subsequent years.

The investigation of the wilt disease, therefore, is of practical importance in the Central Provinces, particularly for the Berars.

SUMMARY OF PREVIOUS WORK ON THE WILT DISEASE.

The wilt disease of cotton attracted the attention of investigators in America as early as the last decade of the last century, and a considerable amount of literature has accumulated on this subject in that country. None of the American literature, with the exception of Erwin F. Smith's paper " On the Wilt disease of Cotton, Water-melon and Cowpea " published in 1899, was unfortunately available to us in the original.

The previous work in the Central Provinces on this disease has been confined to observations in the field and pot-cultures on the susceptibility and immunity of different varieties of cotton. These have resulted in the discovery that indigenous varieties are far more susceptible to the disease than foreign or imported ones.[1] No work on the causal fungus had, however, been done. Nor is it certain that any of the material of cotton wilt which was under study in the laboratory of the Imperial Mycologist between 1916-1919 at Pusa was obtained from the Central Provinces. The Pusa work has apparently been left incomplete, and with the exception of a few notes published in the annual reports of the Agricultural Research Institute, Pusa, the results are not available. It was necessary, therefore, to make a fresh start when one of us took charge of the newly created post of Mycologist to the Government of Central Provinces and was asked to undertake the investigation of this disease.

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[1] Clouston, D. *Ib.*

The results of American and Indian work previously done on the cotton wilt fungus may be briefly stated as follows :—

It has been proved that *Fusarium vasinfectum* Atk. is the cause of the American cotton wilt. It was at first believed that the Indian cotton wilt fungus was identical with the American one, but the work done at Pusa showed that the *Fusarium* associated with the cotton wilt in India is markedly different from the American species. No description or identification of the Indian fungus has, however, been published so far. Both American and Indian experiences with *Fusarium* wilt diseases agree about the impracticability of devising any direct remedial or preventive measures against them, and the only hope in dealing with them is the possibility of discovering immune or resistant varieties. The Americans have already found suitable resistant varieties. In India, previous observers have noted great differences in susceptibility to the disease in the various cottons and the *buri* has been found to behave as immune in the Central Provinces.

THE SCOPE OF THE PRESENT WORK.

The absence of a mycological laboratory at the Agricultural Research Institute, Nagpur, during the time the work recorded in this paper was carried out, together with the possibility of the work being interrupted or having to change hands owing to the impending transfer of one of us from the Central Provinces, imposed certain limitations on the scope of the work undertaken. The previous work on this disease in America and India had moreover shown its agreement in essential particulars as regards the mode of infection and manner of spread in the field with other *Fusarium* wilt diseases previously investigated in different countries, and it seemed unlikely that any further information of practical use in dealing with the disease would be obtained by repeating these observations. It seemed best, in the circumstances mentioned, to restrict the work to a few points connected with the causal fungus and the conditions of the soil and host which encourage or retard its growth. It was also necessary to test by actual inoculations with the fungus the reputed immunity of *buri* cotton.

the previous experiments[1] on this subject having been carried out by using soil from wilted fields in pot-cultures. If the immunity was established, the nature of the immunity had also to be investigated.

It is hoped that a record of the observations made would serve to indicate the lines on which future work on this disease would be carried on most profitably.

THE COTTON WILT FUNGUS.

Examination of wilted cotton plants collected by the Economic Botanist during the previous year (1919) showed a mycelium bearing the *Cephalosporium* type of spores and characteristic chlamydospores and occupying many of the vessels. Not wishing to wait until the parasite could be isolated from freshly attacked plants (for the attack in the field generally becomes apparent in September and October) we used the previous year's material to isolate the parasite from. This was easily done by cutting little bits of roots in which the presence of the fungus had been ascertained, peeling off the bark, washing thoroughly with water and 0·2 per cent. solution of mercuric perchloride and finishing with dipping in alcohol for a few seconds and burning off the alcohol and dropping the bits of roots on slants of agar medium B*. The fungus was killed in some cases by this treatment, but bacteria were successfully kept out.

The fungus in a couple of days grew up to the surface and could then be sub-cultured. Fresh material of wilt became available in abundance later on in July in the Agricultural Chemist's pot-cultures for study of the effect of various soil-treatments on the cotton wilt. In addition to this, a *Fusarium* sp. was isolated from wilt-soil from Akola and cultures were also obtained from the pink incrustation of *Fusarium* spore-beds developed on the surface of wilted plants in the pot-cultures.

[1] Clouston, D. *Ib.*

* Details of the media used in this work will be found in the Appendix (p. 616).

We had thus four strains of *Fusarium* obtained from different sources which will be referred to as I, II, III and IV, respectively, as below :—

I. Fungus obtained from wilted cotton plant collected on the Nagpur Agricultural College Farm in 1919.

II. Fungus obtained from wilted plants in the pot-culture experiments of the Agricultural Chemist, Nagpur. The soil in these pots came from Akola.

III. Fungus isolated from soil from Akola.

IV. Fungus obtained from pink incrustation of *Fusarium* spore-beds developed on the surface of wilted plants in the Agricultural Chemist's pot-cultures.

In the absence of literature and material for comparison, no attempt was made to identify or name the strains, but it was found that strains I, II and III could be easily distinguished from one another by their cultural characters, while strain IV seemed to be identical with II.

Inoculation experiments were carried out with these strains.

Inoculation experiments.

Pot No.	Variety of plant	Date of sowing	Date of inocula-tion	Strain of fungus used	No. of plants in pot at start	No. of deaths due to wilt with dates	Remarks, or method of inoculation, etc.
				EXPERIMENT I.			
1	Roseum	29-6-20	13-7-20	I	11	1 on 23-8-20 1 on 4-9-20 — 2	Contents of a culture tube were broken up in water and mixed with the soil in the neighbourhood of the plants.
2	Roseum	,,	,,	,,	9	1 on 23-8-20 1 on 31-8-20 1 on 2-9-20 1 on 18-9-20 — 4	Strain I was recovered in all the three of the dead plants from which re-isolation of the fungus was made.
3	Buri	,,	,,	,,	5	None	Three pots of *roseum* and two of *buri* which served as control for experiments 1 and 2 remained disease-free.

Inoculation experiments—contd.

Pot No.	Variety of plant	Date of sowing	Date of inoculation	Strain of fungus used	No. of plants in pot at start	No. of deaths due to wilt with dates	Remarks, or method of inoculation, etc.
			EXPERIMENT 2.				
4	Roseum	29–6–20	20–7–20	III	7	None	Method of inoculation same as in experiment 1.
5	Buri	..	..	..	4	..	..
			EXPERIMENT 3.				
6	Roseum	,,	..	II	5	1 on 22–8–20	Strain II was recovered from the dead plant.
7	Buri	..	..	,,	5	None	Controls remained disease-free.
			EXPERIMENT 4.				
8	Roseum	,,	22-7-20	II	5	None	In three of the plants in each pot the fungus was introduced into a puncture made with a sterile needle in the part of the stem in contact with the soil.
9	Buri	.	,,	,,	5	,,	On 12th August, 1920, a few rootlets of the inoculated plants were cut and the fungus placed in contact with them and covered up with soil.
			EXPERIMENT 5.				
10	Roseum	5–8–20	5–8–20	II	8	None	A suspension of the fungus in water was put into the ground along with each seed and bits of cultures were also mixed up with the soil.
11	,,	,,	,,	,,	10	,,	
12	Buri	,,	,,	,,	9	,,	
13	,,	,,	,,	,,	8	,,	
14	Tur (*Cajanus indicus*)	,,	,,	,,	4	,,	
15	,,	,,	,,	,,	4	,,	
16	Gram	,,	,,	,,	10	,,	
17	,,	,,	,,	,,	10	,,	
18, 19, 20, 21	Controls, one pot of each variety of the plants above.	,,			..	..	

Inoculation experiments—concld.

Pot No.	Variety of plant	Date of sowing	Date of inoculation	Strain of fungus used	No. of plants in pot at start	No. of deaths due to wilt with dates	Remarks, or method of inoculation, etc.
				EXPERIMENT 6.			
22	Roseum	27-8-20	27-8-20	IV	6	None	Method of inoculation same as in experiment 5.
23	,,	,,	,,	,,	6	,,	
24	Buri	,,	,,	,,	5	,,	
25	,,	,,	,,	,,	6	,,	
				EXPERIMENT 7.			
26	Roseum	,,	,,	I	1	,,	
27	,,	,,	,,	,,	4	,,	
28	Buri	,,	,,	,,	3	,,	
				EXPERIMENT 8.			
29	Roseum	,,	,,	III	4	,,	
30	,,	,,	,,	,,	5	,,	
31	Buri	,,	,,	,,	6	,,	
32	Roseum	,,	Controls for experiments 6, 7 & 8		3	,,	
33	,,	,,			4	,,	
34	,,	,,			5	,,	
35	Buri	,,			6	,,	

The soil in all the pots in the above experiments was sterilized in the autoclave at 120°C. for 30 minutes. The pots were thoroughly washed and dried in the sun before filling. The seeds were disinfected with 0·2 per cent. mercury perchloride solution.

REMARKS ON THE INOCULATION EXPERIMENTS.

The only positive results obtained were where strains I and II were used, and as the fungus isolated from the dead plants was identical with the strain used as inoculum, it may be concluded that we have come across two strains of *Fusarium* capable of attacking the cotton plant as a parasite. The negative results obtained in the other experiments with these strains are to be attributed perhaps to the time at which the inoculations were made, the season having advanced by that time. The virulence of these

strains as parasites would also appear to be not very marked, and this experience agrees with that at Pusa where also it seemed probable "that the Indian disease is decidedly less virulent than that in the United States."[1] At the same time it should be mentioned here that the strain II, which had been undoubtedly living in the soil in the pots of the Agricultural Chemist's experiments for three years, behaved as a virulent parasite on the *roseum* variety, killing all the plants grown in many of the pots. It seems possible from this observation that the fungus loses its virulence as a parasite when cultivated on artificial media.

The negative results in inoculation experiments do not prove anything and these experiments must be repeated in any future work on this disease, particularly with the strain IV which, in cultural characters, is indistinguishable from strain II and which was derived from *Fusarium* spores developed on the surface of plants which had undoubtedly died of the fungus.

TWO STRAINS OF THE COTTON WILT FUNGUS.

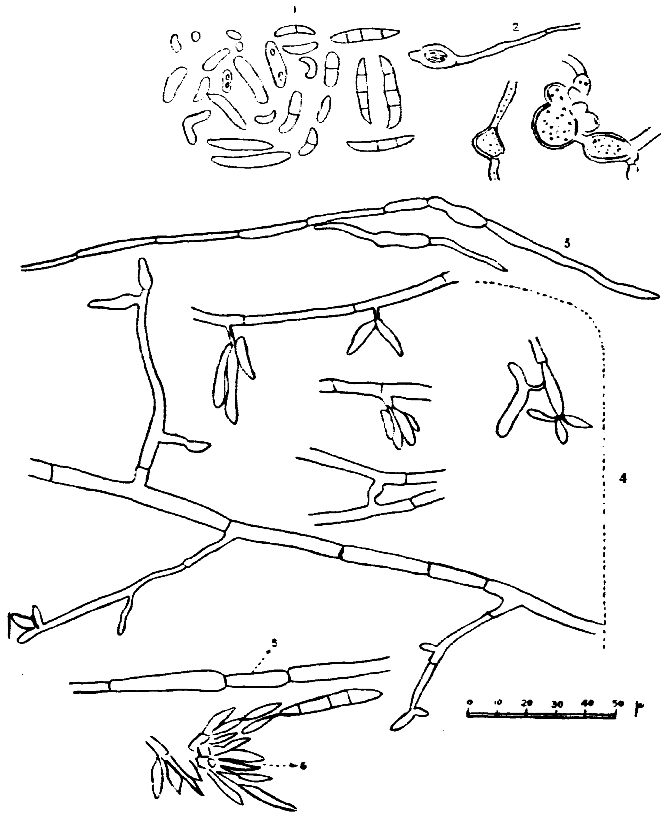
The two strains of the cotton wilt parasite, the parasitism of which was established, may now be briefly described.

Plate XXXIII illustrates the various spore forms and mycelial characters occurring in the two strains. In size, shape and variety of spore forms all of which occurred on media B and D, and in the general course of the life-history, these two strains are perfectly similar to each other. The difference comes in when the formation of sclerotium-like bodies occurs, and then these and the sclerotial crust at the base of the agar-slant are distinctly coloured dark-blue or bluish-green in strain I, while in strain II they remain whitish or at best pale brown (Plate XXXIV, fig. 1). These differences were constant in cultures of the two strains on media B and D and suggested comparison with the coloured and colourless sclerotia of strains of *Botrytis cinerea* described by Brierley[2]. Further observations on

[1] Butler, E. J. *Rept. Agri. Res. Inst., Pusa*, 1913-14, p. 55.

[2] Brierley, W. B. On a form of *Botrytis cinerea* with colourless sclerotia. *Phil. Trans. Roy. Soc. of London, Ser. B*, vol. 210, pp. 83–114.

Strain I.



Strain II.

Cultural characters of cotton wilt *Fusarium*. 1, Micro- and macro-spores; 2, Chlamydospores; 3, Germinating microspores; 4, Microspore-formation; 5, Characteristic swelling of hyphæ near septa; 6, Macrospore-formation.

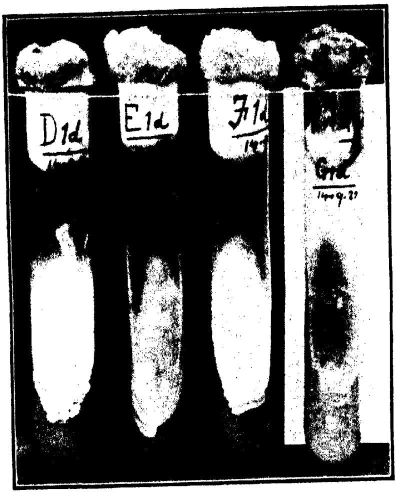


Fig. 1. Growth of Strain I on media D. E. F and G; sclerotial bodies indicated rather faintly as black dots in tube D1d.

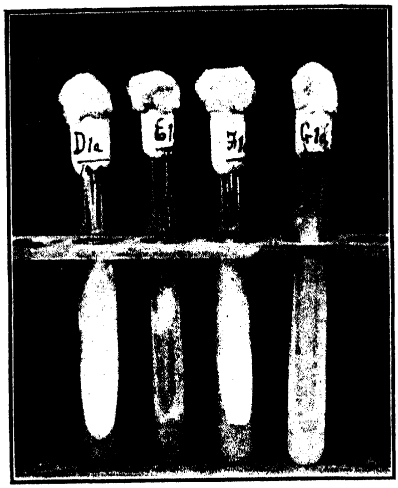


Fig. 2. Growth of Strain II on media D. E. F.G.

Fig. 3. Section through two sclerotial bodies from Strain I.

Fig. 4. Growth of cotton plants in sterilized (A) and in unsterilized (B) soil.

COTTON WILT *FUSARIUM.*

cultures on different media, however, point to the possibility of strain II being induced to develop a blue or purple colour in its sclerotia under certain conditions and also to the inhibitive effect which certain cultural conditions seem to exercise on the capacity for colour production in strain I. Strain I, for example, generally failed to develop colour on medium F, and strain II invariably developed a blue or purple colour in its sclerotia on medium G. As it is intended to pursue the interesting line of investigation suggested by these observations and as the technical description of the strains has to be deferred until favourable opportunities for comparison with other forms become available, we merely record the occurrence of these two strains.

No kind of spores have been seen to develop either in or on these sclerotial bodies, but the fact that they invariably show a cavity enclosed by a pseudo-parenchymatous wall suggests that they are probably of the nature of pycnidia or perithecia (Plate XXXIV, fig. 3). They may be formed separately or may be grouped together in numbers, particularly in strain I. The size of a single one of these bodies may be roughly stated as that of a pin-head, but the groups are variable in size and may reach that of a mustard seed or even a pea.

It should be added that the colour-producing strain was obtained in one only of the several isolations of the cotton wilt parasites obtained directly from wilted plants which were collected from various localities, *viz.*, Nagpur, Akola and Ellichpur.

Strain II, indeed, seems to be the common form of the parasite and strain I the exceptional one. It is interesting in this connection to mention that the fungus which one of us obtained in 1912 from wilted cotton plants from Dhulia in the Bombay Presidency agreed in characters with our strain II. The sclerotial bodies, coloured or colourless, have not been so far observed on or in the cotton plant.

Study of the cotton wilt fungus in cultures.

Our further studies were confined to strains I and II whose parasitism had been established in the inoculation experiments. The

question of the identification of these strains having to be deferred for the reasons stated above, we have not followed the usual procedure of growing the strains on standard media. The media used in our cultures were designed to ascertain the response of the fungus to the chief manurial constituents K_2O, N and P_2O_5; and to the plant juices from the susceptible *roseum* variety and the immune *buri* variety. From the information obtained on these points it was hoped some light would be thrown on the possibility of dealing with the fungus by manurial treatment of the soil and also on the nature of the susceptibility or resistance to the disease of different varieties. A common belief among cultivators and even trained observers that heavy manuring, especially with cattle dung and urine-earth, encourages the wilt disease, had also to be tested and explained, if true. If different plant juices made any difference to the fungus as regards its growth, and if this difference could be traced to a difference in the composition of the plant juice, we should be in a position to class varieties as resistant or susceptible much more readily than at present.

The following culture-media were accordingly prepared :—

Medium	D	containing	$K_2O + N + P_2O_5$
"	E	"	$K_2O + P_2O_5$
"	F	"	$K_2O + N$
"	G	"	$N + P_2O_5$

The growth on these media showed marked differences (Plate XXXIV, figs. 1 and 2), the best being that on the complete medium, the next best that on F, while that on E and G was very poor. The fungus being a soil-dweller, the observation that it is sensitive to the important manurial constituents suggested the possibility of continued treatment with artificial manures for a number of years altering the manurial composition of the soil materially so as to encourage or retard the growth of the wilt fungus. We were fortunate in having on the Nagpur Agricultural College Farm permanent manurial plots under cotton, each of which had received a certain manurial treatment continuously for the last 10 years, and the idea occurred to utilize the soil

solutions from these plots as culture media. The following media were accordingly prepared :—

Medium	M	from	plot receiving	super, nitrate and potash.
,,	N	,,	,,	super and nitrate.
,,	O	,,	,,	potash and nitrate.
,,	P	,,	,,	super and potash.

We were rather disappointed with the results of the attempt to grow the fungus strains on these media. There was very poor growth on every one of these media and the fungus in every case seemed quite starved and appeared to try to save itself by the formation of chlamydospores. It was suspected that this was due to the absence of organic substances in the soil solution, and for this reason, as well as to test the truth of the prevalent belief that manuring with urine-earth and cattle dung encouraged wilt attack, another trial was made to grow the fungus on soil solution obtained from a plot on the Nagpur Agricultural College Farm which had received heavy dressings of cattle dung, *til* (*Sesamum*) cake and urine-earth for two years previously. Here also, the growth was very poor and showed no advantage over the other soil solutions previously used. These experiments are, therefore, so far inconclusive. It is possible that the poor growth of the fungus may be explained by the fact that the soil solutions experimented with had been obtained from the plots at nearly the end of the season when the crops growing on these might presumably have exhausted the principal manurial requirements. It might also be that the soil solutions, obtained in the way they were, did not contain enough organic substances for the fungus, and such nutrient substances as were present were soon used up by the fungus and could not be replenished owing to the absence of the biochemical reactions ordinarily going on in the soil. Further observations on the growth of the fungus on soil solutions are, therefore, necessary.

In order to see how far the composition of the plant juice derived from the host plant could explain the susceptibility or resistance of a variety of cotton, media J, J_1 and K, K_1 containing *buri* and *roseum* juices, respectively, were used. In addition, partially sterilized *buri* and *roseum* stems were also dropped on plain (with

no nutrient substances) agar-slants and used to grow the fungus on. The fungus grew equally well in all the tubes of the plant juices and penetrated freely into both the *roseum* and *buri* stems. The composition of the juices in the host plant, therefore, seems to offer no clue to the nature of resistance or susceptibility.

THE CAUSE OF THE WILTING.

Another point which occurred to us as requiring study was the exact cause of the wilting of cotton plants attacked by the fungus. Is it merely mechanical, the blocking up of the vessels by the fungus as suggested by E. F. Smith[1] and commonly believed, or might it be due to the secretion of any toxins, as was proved by Hutchinson[2] in the case of the bacterial wilt of tobacco ? Ordinary microscopic examination of sections of wilted plants enabled one to trace the fungus to within three inches of the top of a dead plant, and more elaborately prepared sections might perhaps show the fungus still further up, especially with the aid of stains. But although every section showed some of its vessels occupied by the fungus, it at the same time showed a much larger number which seemed quite empty, and the suspicion arose that the mechanical blocking up of the vessels was not so complete as to account for the wilting effect and that in addition to robbing its host of food and water the fungus possibly also secreted some toxins which brought about the death. To ascertain this the following experiment was done.

Strain I was inoculated into two tubes of medium L (Peptone bouillon). One of these intended to serve as control was sterilized after the addition of the inoculum. The fungus was allowed to grow for 20 days. 95 per cent. alcohol was then added to the liquid in the two tubes, and the precipitate obtained in each case was washed on filter paper three times with alcohol and then dissolved in sterile distilled water. The two solutions obtained were then

[1] Smith, E. F. On the Wilt Disease of Water-melon *Bull. No.* 17, *U. S. Dept. Agri., Division of Vegetable Physiology and Pathology*.

[2] Hutchinson, C. M. *Mem. Dept. Agri. Ind., Bact. Ser.*, vol. 1, no. 2, 1913.

fed to two *roseum* plants in pots in the way described by Hutchinson.[1] No wilting was observed in either plant even after three weeks, although all the solution fed to the plants was certainly absorbed. Experiments with larger quantities of the supposed toxins and with younger plants than in our experiment (our plants were three and a half months old) seem to us necessary to settle this point.

METHODS OF DEALING WITH THE COTTON WILT FUNGUS.

Fusaria causing wilt diseases of crops are soil-dwellers and can live in the absence of the host plant in the soil. That the cotton wilt fungus is no exception to the rule is seen from the pot-culture experiments carried out between 1910–12 by Mr. Clouston[2], then Deputy Director of Agriculture, Central Provinces, and again from those carried out by the Agricultural Chemist, Nagpur, between 1916–19. In both these series of experiments it became obvious that soil from a wilted area could produce the disease in cotton plants grown in it. Experience in the field corroborates that in pot-cultures, and in many places some fields have come to be notorious as wilt-areas. It seemed obvious, therefore, that the only feasible methods of dealing with the wilt disease were (1) some form of soil treatment which would either kill the fungus or which would render the soil an unsuitable medium for the fungus to live in and (2) the growing of immune varieties.

SOIL TREATMENT.

During the last three years, the Agricultural Chemist, Nagpur, has carried out a series of pot-culture experiments to test the efficacy of different soil treatments against the cotton wilt, and although some of these are still in progress, we have been kindly allowed by that officer to include here the following summary of the results obtained from these experiments.

" At the suggestion of Dr. Butler, sulphuric acid, copper sulphate and super were tried in 1918 and 1919 as fungicides against cotton

[1] Hutchinson, C. M. *Ib.*
[2] Clouston, D. *Ib.*

wilt in pot-cultures. As these chemicals were found to have absolutely no effect, the experiment was discontinued.

"A second set of experiments was started in 1918 and repeated in 1919 wherein wilt soil subjected to partial sterilization was used for pot-cultures. The treatment given to wilt soil was as follows :—

(1) soil heated in steam for 3 hours.				
(2)	do.	to	100 C. dry heat for 3 hours.	
(3)	do.		85 C.	do.
(4)	do.		65 C.	do.

"The results obtained from the last 2 years' pot-culture work seem to indicate that heating the soil has some effect, but as the results were not conclusive, the experiment is being continued this year."

It would appear from the above that sterilization of the soil, if it could be practicable on a large scale, would be one of the methods of dealing with the fungus. But apart from the doubtful practicability of such sterilization on a large scale, it must be remembered that the degree of sterilization which would be necessary to kill out the fungus would also kill all the useful micro-organisms of the soil and would render it infertile. In this connection we may state our experience with our cultures of cotton in completely sterilized soil for inoculation experiments. The seedlings which grew normally as long as they drew nourishment from the parent seed soon showed symptoms of starvation and looked very unthrifty. The addition of a dose of sodium nitrate immediately enabled the plants to pick up. Plate XXXIV, fig. 4 shows the marked difference in growth between plants in sterilized and unsterilized soils. Since, however, even the partial sterilization of the soil may be expected to reduce the chances of infection, the experiments with burning cotton-stalks on wilted fields which have been carried on by the Deputy Director of Agriculture, Western Circle, Central Provinces, since 1919, are of great interest. The first year's results, as we have been informed by the officer just mentioned, have given distinct indications in favour of this practical method of sterilization, but the experiments must be

carried on for several years before any definite conclusions can be drawn from them.

As regards manurial treatment of the soil against the cotton wilt fungus, our experience with cultures of the fungus makes us very doubtful as to the success of such treatment. It would seem, on the contrary, that any treatment of the soil which would supply the cotton plant with all its manurial requirements would at the same time give the wilt fungus a favourable medium to grow in. The very poor growth of the fungus on soil-solutions obtained from the permanent manurial plots manured continuously with artificial manures for a number of years would have been an observation of some practical value if the growth of the fungus on soil-solution obtained from the plot manured heavily with cake, farmyard manure and urine-earth had been any better. Further study of cultures of the fungus on soil-solutions obtained from the plots immediately after the manure is added to them, and not at the end of the season as in our experiments, may throw some more light on the comparative effect of natural and artificial manures on the incidence of the wilt.

There is no indication so far that the cotton wilt is a "deficiency" disease, *i.e.*, a disease which occurs on the host plant when it suffers from malnutrition owing to the deficiency in the soil of some important manurial constituent. Our observations on this point are, however, limited, being confined to the behaviour of the cotton plants growing on the permanent manurial plots on the Nagpur Agricultural College Farm, which have been so arranged that while in some all the manurial constituents are supplied, in others one or more of them are omitted, and this treatment has continued for the past 10 years. No appreciable difference in the incidence of wilt on these plots was noticed this season. Further observations on this point continued for several years are, however, necessary, before a definite statement can be made.

Immune varieties.

There remains the consideration of immune varieties as the hope against the cotton wilt. Here the prospect appears more

cheerful. All the observers that have preceded us agree that most of the foreign or imported varieties are markedly resistant. One of these—the *buri* cotton—has been particularly closely watched since 1908, and has proved remarkably resistant, almost immune.

In Mr. Clouston's pot-culture experiments alluded to already, not a single case of wilt occurred in the *buri* plants grown in wilt-soils in pots, whereas the majority of the *jari* and *bani* plants which had been grown for comparison succumbed to the disease. This experience was repeated in the Agricultural Chemist's pot-culture experiments. No death from wilt of a *buri* plant occurred in these, although *roseum* plants which were grown in exactly similar conditions died in large numbers. In order to further convince ourselves as to the immunity of *buri* and also to test the heritable nature of the resistance of individual *roseum* plants surviving in a badly wilted field, we performed the following experiment.

Eight pots were selected from the Agricultural Chemist's experiments in which all the *roseum* plants had died from wilt within two months from sowing, thus showing the presence of the parasite in them in a very virulent form. Seeds of cotton were planted in these as detailed below :—

Pot No.	Date of sowing	No. of seeds sown	Description of seed	No. of deaths from wilt	Remarks
43*	4-8-20	9	Seeds from a *roseum* plant perfectly free from wilt in a badly infected wilt plot.	9	The seeds were washed in 0·2 per cent. solution of mercury perchloride previous to sowing. All seeds sown germinated.
47*	,,	9	From another *roseum* plant as above.	9	
42*	,,	9	Seeds from a *roseum* plant which showed wilt at an advanced age and ultimately died from it.	9	
44*	,,	7	Seeds from the disease-free part of a partially wilted plant.	7	
41	,,	6	*Roseum*	5	
46	,,	6	*Buri*	None	
49	,,	6	,,	,,	
45	,,	6	,,	,,	

* Seeds for these pots were supplied by Mr. D. G. Sawargaonkar, Agricultural Assistant, Akola Farm.

While this experiment shows that a plant which has stood free from the disease in the field in the midst of wilted plants does not necessarily give rise to disease-resistant offspring, at the same time it confirms the remarkable resistance of *buri* cotton previously noted by other observers. In our direct inoculations with the fungus, not a single death occurred among the *buri* plants. The failure of the rains during this season (1920) over the greater part of the Berars rendered it impossible for us to make any useful observations in the field on the behaviour of various kinds of cotton towards the wilt, the crop having dried up in many cases owing to the drought. An observation made on the Akola farm in the beginning of November 1920, may, however, be recorded here for what it is worth. Some twenty plants of *buri*, which appeared to have died prematurely owing to some disease, were examined. The great majority of them showed insect attack at the roots and only two of them showed a mycelium in the vessels. On this being isolated, it proved to be a *Fusarium* in one case and a fungus with dark coloured mycelium and sclerotia and spores in the other. The *Fusarium* differed but slightly from strain II in cultural characters, but the proof of its parasitism must be deferred till another season. The behaviour of the *buri* plants in the experiments under control and the occurrence of an altogether different fungus in one of the two specimens from which the fungus was isolated makes it more probable that the *Fusarium* obtained from the *buri* plant in question entered it rather as a saprophyte than as a parasite, and we are therefore justified in concluding that *buri* is indeed very resistant, if not absolutely immune, to wilt. Further observations which will have to be continued over several years would no doubt discover resistance to wilt disease in other types of cotton, and material would thus be obtained for the plant-breeder to develop suitable types of cotton from the existing ones which would combine resistance to wilt with other desirable characters.

In conclusion, we wish to express our gratitude to Mr. A. R. Padmanabha Aiyer, Offg. Agricultural Chemist, Nagpur, and Mr. K. P. Shrivastava, Offg. Economic Botanist, Nagpur, for placing

portions of their respective laboratories at our disposal and for much assistance during the progress of the work.

SUMMARY.

(1) Two strains of a *Fusarium* sp. have been isolated from wilted cotton plants and their causal connections with the wilt disease established in inoculation experiments.

(2) In addition to the usual *Cephalosporium* and *Fusarium* type of spores and chlamydospores, these two strains produce on culture media sclerotium or perithecium-like bodies which enclose a cavity within a pseudo-parenchymatous wall. No kind of spores have, however, been observed either in or on these bodies.

(3) The two strains differ from each other only in one particular—the colour of the sclerotium-like bodies. It is dark-blue or bluish-green in one and whitish or pale-brown in the other.

(4) The behaviour of the two strains on media designed to ascertain their response towards the chief manurial constituents P_2O_5, N and K_2O, and towards the plant juices of the susceptible *roseum* and the resistant *buri* varieties of cotton, was studied.

(5) The reputed immunity of the *buri* cotton was tested and confirmed.

(6) An attempt to ascertain if the wilting of the cotton plant was due to any toxins secreted by the fungus gave negative results.

(7) The feasibility of different suggested methods of dealing with the disease in the field is discussed in the light of the observations recorded.

APPENDIX.

Details of the culture-media referred to in the paper.

			Reaction
Medium B	Peptone Lemco NaCl Glucose Agar Water	.. 10 grm. .. 4 ,, .. 5 ,, .. 20 ,, .. 20 ,, .. 1,000 c.c.	Alkaline to litmus.

APPENDIX—*concld.*

		REACTION
Medium C	$MgSO_4$ .. 0·5 grm. K_2HPO_4 .. 1·0 „ KCl .. 0·5 „ $FeSO_4$ .. 0·01 „ $NaNO_3$ .. 2·0 „ Cane sugar .. 30·0 „ Agar .. 20·0 „ Water .. 1,000 c.c.	
„ D	$MgSO_4$ .. 0·5 grm. Na_2HPO_4 .. 1·0 „ KCl .. 0·5 „ $FeSO_4$ .. 0·01 „ $NaNO_3$ .. 2·0 „ Sucrose .. 20·0 „ NaCl .. 0·5 „ Agar .. 20·0 „ Water .. 1,000 c.c.	Almost neutral.
„ E	Same as D without Na_2HPO_4	2 Fuller.
„ F	Same as D without KCl	2 Fuller.
„ G	Same as D without $NaNO_3$	2 Fuller.
„ J	*Buri* plants were selected and the stems and petioles were pounded in a porcelain mortar and the juice was expressed by a hand mill. It was then filtered through washed and sterilized Berkfield filter candles into sterilized filter flasks with the aid of the filter pump. 4 c.c. of the sterile juice was then added to each test tube containing 8 c.c. of 2 per cent. solution of sterile agar at 40°—45° C. The agar was then made into slants and these were kept for 48 hours. The slants thus prepared remained free from any bacterial contamination, and were used for the respective inoculation experiments.	
„ J 1	The expressed *buri* juice was directly added to tubes containing 2 per cent. agar solution and sterilized in the autoclave at 120°C. for 20 minutes.	26 Fuller.
„ K	Same as J except that the juice was from *roseum* plants.	26 Fuller.
„ K 1	Same as J 1 except that the juice was from *roseum* plants.	
„ L	Peptone 10 grm. Lemco 4 „ NaCl 5 „ Water 1,000 c.c.	Slightly alkaline to litmus.
„ M	2 per cent. agar solution made in water extract of the soil from plot 1, L series (Agricultural College Farm, Nagpur) receiving super, nitrate and potash. The water extract was obtained by shaking 100 grm. of soil with 200 c.c. of water and allowing to stand for 20 hours and then filtering.	Neutral to phenolphthalein. (M–Q)
„ N	Same as M except that the soil was from plot 2, L series, receiving super and nitrate only.	
„ O	Same as M except that the soil was from plot 3, L series, receiving potash and nitrate only.	
„ P	Same as M except that the soil was used from plot 5, L series, receiving super and potash only.	
„ Q	Same as M except that the soil used was from plot 7, O series, receiving cattle dung, urine-earth and *til* cake.	

SOME PRELIMINARY EXPERIMENTS WITH JUTE IN THE UNITED PROVINCES.

BY

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AND

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SOME small experiments made a few years ago at the instance of Mr. R. H. L. Clarke, then Deputy Commissioner of Bahraich District, suggested that jute could be successfully grown in portion of that district. In the course of a tour made by one of us in early 1920 in a similar tract in the Sitapur District, separated from Bahraich by the river Gogra, it became apparent that this tract, locally known as the *ganjar*, was badly in need of a commercial crop ; prospects for jute seemed favourable and arrangements were made with the Court of Wards for a series of experiments to test the matter further.

It may be explained that the area known as the *ganjar* extends through considerable portions of the Kheri, Bahraich, and Sitapur Districts, and consists largely of the land lying in the angle between the Sarda and Gogra rivers and of the low land on either bank. The beds of these rivers are broad and ill-defined, numerous tributaries and alternative channels intersect the tract between and adjoining them and there are numerous old beds. As a result, this tract is liable to intermittent flooding in the monsoon. In

favourable spots rice and *kodon* (*Paspalum scrobiculatum* Linn.) are grown, but all *kharif* cultivation is somewhat precarious owing to the variable nature of the floods and the varying character of the deposits of sand or silt from the river.

Winter cultivation on the other hand is subject to the action of several limiting factors. When the floods recede late or the monsoon is prolonged, there is little time for the preparation of land for *rabi* crops. On the other hand, except on manured land near village sites, owing to the light character of the soil, moisture fails in years when no winter rain falls and the crops raised are small.

As one leaves the rivers, moving either east or west, the *ganjar* proper shades into a class of land locally known as the *terai* which is free from flooding, of admirable texture with a high subsoil water level and which produces excellent crops of tobacco, sugarcane and maize. The *terai* in turn is separated from the high lands locally known as *uparhar*, characteristic of the greater part of the Sitapur District, by a distinct bank running roughly parallel to the rivers for a distance of some 150 miles.

It was decided to grow test plots of jute at various places throughout the *ganjar* area including the edge of the *terai* and to scatter these in different villages in such a way as to sample the tract thoroughly. Arrangements were made with the Special Manager, Court of Wards estates, Mr. W. C. G. Dunne, M.B.E., for the growing of jute on tenants' fields in suitable villages of the Katesar and Rampur Mathura estates, cultivators being guaranteed against loss on the experiment. The Agricultural Department provided seed, manure (castor cake) and demonstrating staff to supervise the preparation of the land, sowing, weeding and retting, and also undertaking the marketing of the fibre produced.

In the Katesar estate work centred round Shahpur, a large village near the right (west) bank of the Chauka, but including villages further west on the edge of the *terai* and further east between the Chauka and Sarda.

In Rampur Mathura, experiments were carried out in the typical *ganjar* between the two rivers and near their junction.

An agricultural assistant was kindly lent by the Government of Bengal to assist in the selection of fields for trial plots, as also a jute demonstrator who worked throughout the season supplemented by a special jute fieldman and another demonstrator for stripping and retting.

In all some 60 experimental plots were arranged, aggregating about 12 acres.

Both *capsularis* and *olitorius* jute were tried, the seed supplied being Dacca pure line selections; particular attention, however, was paid to *capsularis* jute.

A certain number of plots failed entirely due to neglect, several being grazed by cattle when young owing to the absence of fences. In several other cases it was decided when we both inspected the plots in August that in view of the scanty germination it would be better to allow these to stand for seed instead of cutting them for fibre production. The results from certain other plots were uncertain owing to difficulties in inspection, but definite results were obtained from fifteen plots in the Shahpur (Katesar) area and eight plots in the Rampur Mathura estate which are reproduced below.

Plot number	Village	Position	Yield per acre (maunds of jute)	REMARKS
		Katesar estate; capsularis *jute*.		
1	Amba	Edge of *terai*	25	Sown with irrigation and irrigated before rains.
2	"	" "	6½	Sown with irrigation.
3	Hazaripore	" "	7	" "
4	"	" "	12½	" "
5	Shahpur	" "	13¼	" "
6	Shikhnapore	Edge of *ganjar*	13½	....
7	Kuseppa	Typical *ganjar*	29	March Sown } *Kodon* land.
8	"	....	20	April Sown } *Kodon* land.
9	"	....	8¾	Weeding neglected.

Plot number	Village	Position	Yield per acre (maunds of jute)	REMARKS
		Katesar estate; capsularis *jute.*		
10	Kuseppa	....	4½	Preparation careless, grew well, "stand" thin.
11	Daheli	Edge of river, sandy.	2½	Weeding neglected.
12	Samodidih	Typical *ganjar* (trans-Chauka)	29	*Olitorius* jute.
13	Shahpur Khurd	Edge of *terai*	10	....
14	" "	..	8½	....
15	" Khas	..	6½	....
		Rampur Mathura estate; capsularis *jute; no irrigation.*		
16	Hariharpur	Typical *ganjar*	17½	....
17	Ramnipur	..	11	Stand irregular.
18	"	..	12	Stand irregular.
19, 20, 21	Daimalpore	..	22½	....
		Rampur Mathura estate; olitorius *jute; no irrigation.*		
22	Niharwal	..	15½	....
23	"	..	16¼	....

On the whole, more information was gained from a detailed inspection of a number of experimental plots in August than from the actual yields.

In the *terai*, jute to be successfully grown requires irrigation and, as maize grows well in average years without irrigation, it is doubtful if jute would be an economic success since the labour of irrigating from small shallow wells is considerable. On the actual fringe of the river also jute failed owing to the excessive proportion of sand in the soil. But on the typical *kodon* land in the real *ganjar* area, where no *kharif* crop of importance can be grown owing to the uncertainty of the degree of flooding, jute grew extremely well with no irrigation wherever reasonable care was given to the crop in its early stages.

Through the courtesy of Messrs. Sinclair Murray and Co. and of Messrs. George Henderson and Co., a detailed broker's report of the Shahpur jute was secured.

The preliminary examination in January 1921 gave the following results :—

Bale No. 3. Length good, no root, colour very good, strength good, good spinning quality, practically "fours" (4's) quality on account of light cuttings. Good balers' (export) jute. Value Rs. 15 per maund.

Bale No. 7. Shorter and colour not so good, no root, strength good, good spinning quality, averaging "5's." Value Rs. 11 per maund.

Bale No. 13. Not so good, length medium though longer than No. 7, more root, better colour, some runners (middle bark) average about "5's." Value Rs. 10 per maund.

Bale No. 12. Length good, fairly heavy root, oversteeped and weak in places, colour poor. Value Rs. 12 per maund.

Bale No. 7 was jute grown with irrigation at the Cawnpore farm, Bale No. 12 mixed sample of *olitorius* from Shahpur, Bale No. 3 part of the Samodidih jute from Shahpur.

Finally, an "overhead" price of Rs. 12 per maund was paid for this jute which is satisfactory considering that Bengal jute varied from Rs. 4 to Rs. 20 per maund at that time, low qualities being almost unsaleable.

Through the kindness of Messrs. George Henderson and Co. the jute was further examined, sorted and spun in their South Barnagore Mill, and their detailed report being of exceptional interest is reproduced in full :—

Report on Jute grown in the United Provinces.

"With reference to the 13 bales of jute grown in the United Provinces and forwarded to our mills for valuation purposes, we beg

to give below a short report on the quality of this jute from the manufacturing point of view.

"The bales were marked and weighed as follows :—

					Md.	Sr.
1 Bale,	A1,	Sitapur District, *capsularis* jute.	Gross	..	2	12
6 Bales,	A2,	Ditto	,,	..	22	16
2 ,,	B,	Ditto	,,	..	9	12
1 Bale,	C,	Ditto	,,	..	3	16
1 ,,	D,	Cawnpore farm, *capsularis*	,,	..	3	6
1 ,,	E,	Sitapur, *olitorius*	,,	..	3	32
1 ,,	F,	Cawnpore farm, *olitorius*	,,	..	3	16
					47	30

"The bales marked A1, A2, B, C, and D contained a fairly high coloured jute and in selection we obtained the following :—

	Md.	Sr.		
Suitable for hessian warp	28	9	60	per cent.
,, ,, ,, weft	12	34	29	,,
,, ,, sacking warp	3	10	6	,,
,, ,, ,, weft	2	26	5	,,
	46	39		

the balance of weight representing the packsheet and iron hoops.

"The hessian warp and weft jute was sufficient to enable us to run same over a system of our machinery, and we enclose herewith samples in triplicate of the following which we were able to manufacture :—

48 lb.	Rove yarn.
55 ,,	,, ,,
72 ,,	,, ,,
9 ,,	Hessian warp yarn.
12 ,,	,, weft ,,
40 ,, 12 oz.	Hessian cloth.

"In connection with the manufacture of the above, the Mill Manager writes as follows :—

"'The jute was found to be very hard and of a crisp * and wiry nature. It would not be advisable to use same alone, but as a hard jute could be mixed through the batch in small quantities. If used by itself, the wear and tear to the machinery would be considerably increassd owing to the hardness of the fibre. The rove produced was very regular, too hard, and very hairy.'

* Possibly a seasonal effect due to drought. [B. C. B.]

" The rove referred to here is that from which the warp and weft yarns were made and should not be confused with the samples of rove yarn sent herewith, which were made on a special ' spinning roving machine. '

" You will observe from the samples enclosed the hairy appearance of the threads. The samples of cloth were passed through a cropping machine and were also heavily calendered, but this has not had any appreciable effect on the appearance of the cloth.

" Summed up, the jute is a considerable improvement on the ' Meshta ' quality received in the past from the United Provinces, and while ' Meshta ' peculiarities are apparent in the jute under review, still we think it could be marketed in Calcutta at a price the equivalent of a good × 4* and only suitable for mixing purposes.

" Regarding the 11 bales which were subsequently received from the Rampur Mathura estate, details as per letter No. 3356, dated 10th January, 1921, from the Deputy Director of Agriculture, Cawnpore, to you, the less said about the quality the 10 bales marked A, B, C, and D contained the better. The jute was harsh, very badly retted and entirely unsuitable for manufacture. The bale marked E containing jute grown on the Cawnpore farm from *olitorius* seed was, however, different, the fibre being regular, clean and of Tossa appearance, yielding about 60 per cent. sacking warp."

As a result of the unsatisfactory report on the Rampur Mathura estate jute, enquiries were made and it was found that considerable difficulty had been experienced in the supervision of the retting. This estate is difficult of access, particularly during the monsoon, communications were bad and the local demonstrating staff and the cultivators suffered somewhat severely from malaria. Retting demonstration clearly left much to be desired.

With reference both to the yields and to the quality of the jute, it may be pointed out that the season was unusually unfavourable to jute. Monsoon rainfall ceased abruptly at the beginning of August and this undoubtedly affected the plant. In fact, it was

* × (or " cross ") 4's equivalent to " 5's." This quality was worth from Rs. 8 to Rs. 12 when the jute arrived in Calcutta. Prices are now a little down.

somewhat of a surprise to find that it had done so well. The early cessation of the rains led to local shortage of water for retting and to some shortage of labour owing to *rabi* operations starting earlier than usual.

Nevertheless, these experiments have shown that *on suitably selected land* marketable jute can be profitably grown in this tract. Success in introducing the crop will largely depend on whether local cultivators can be persuaded to pay sufficient attention to proper cultivation and to the retting. These trials aroused considerable local interest and a number of applications for jute seed were received from taluqdars and zemindars in the Kheri and Sitapur Districts. It was decided, however, to advise applicants to wait until experiments had been conducted for another year in the Katesar and Rampur Mathura estates.

The writers desire to acknowledge the assistance rendered by Mr. Dunne, M.B.E., Special Manager, Court of Wards, Sitapur, without whose co-operation and personal interest these experiments would have been impossible. Also the work of M. Imam Ahmed, Agricultural Inspector, Sitapur District, who was in immediate charge of the demonstrations.

DISEASE IN PLANTS.*

BY

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Imperial Economic Botanist.

THE great need in agricultural investigation in the present state of our knowledge is a wide outlook. This is particularly necessary in the case of the young investigator taking up research work in one of the scientific branches of the subject. Several factors tend to narrow rather than to widen the general outlook. In both the Universities and in the Agricultural Colleges, the curriculum has to be subdivided and the various sciences bearing on agriculture have to be presented in piecemeal fashion. There are so many subjects to be considered and so much instruction that little time is left for spontaneous thought by means of which the various fragments can be worked up into a complete picture of the subject. The brain of the young graduate is apt to resemble a honeycomb with separate compartments for chemistry, physics, botany and so on. When, however, we come to the actual problems in agriculture which require investigation, a little consideration will show that this division of science into distinct compartments, which was so convenient in the class room, no longer meets the case. We cannot, for example, separate a crop from the soil or consider its growth without reference to the seasons, to the supply of water and other food materials and to factors like temperature. If we follow a wheat crop from sowing time to harvest and consider it in

* A lecture delivered at the Victoria Institute, Nagpur, on Aug. 1st, 1921. The subject has been dealt with in greater detail in a paper entitled—The influence of soil factors on disease resistance—published in the *Annals of Applied Biology*, vol. VII, no. 4, 1921, p. 373.

relation to the environment, we perceive at once that the plant does not recognize our divisions of science and that it has no separate chemical or botanical existence. There is often a further complication. In nearly all cases, the investigator of economic problems has to take into consideration the character and aptitude of the cultivator, the means at his disposal and the uses to which the crop is put. Thus crop production, regarded as a whole, is an exceedingly complex thing. I venture to suggest therefore that the various problems which arise with regard to crops should not be viewed from too narrow a standpoint and that in their investigation, knowledge from as many sides as possible should be brought to bear.

I propose to illustrate the complexity of agricultural problems and the necessity of wide knowledge in their investigation by some examples taken from plant diseases. At one period, plant diseases were regarded as comparatively simple troubles caused by the attack of an insect or a fungus, the obvious remedy for which was either the destruction, at the weakest point in its development, of the insect or fungus concerned or the prevention of infection. Such remedies, however, proved very difficult to apply in the case of ordinary crops as the labour and expense involved are generally greater than the value of the produce to be saved. It is only in special cases like hop-cultivation in Great Britain, where large sums are spent every year in raising the crop, that systematic preventive spraying and powdering are practicable. What is possible in such cases could not be recommended in the case of a wheat crop in the Central Provinces where the total produce in a good year may not exceed eight maunds of grain to the acre.

Rust in wheat.

The comparative failure of direct methods of controlling disease attracted attention to the disease resistant variety which, at the present time, is a very fashionable remedy particularly against wheat rust. As is well known, the unit species of the wheat crop differ greatly in rust resistance. By the substitution of the general mixed crop by a rust resistant type we can sometimes successfully

dodge the disease. If, however, we pursue this matter further we find what at first sight appeared to be a solution of a difficulty is nothing more than an extension of the problem. It was soon found that rust resistance varies according to the locality and to the way the crop is grown. It is not a hard and fast character. Thus at Pusa, a unit species with a fair degree of resistance when grown (1) in flower pots, (2) on heavy land with deep cultivation after the rains and (3) on heavy land without deep cultivation after the monsoon shows great differences in the amount of rust. In flower pots and after thorough preparation, the rust attack is negligible. When sown in land badly prepared, the same variety is sometimes destroyed by rust. The amount of damage from the fungus appears to increase as the physical texture and aeration of the soil fall off. The amount of rust on wheat therefore depends firstly on the kind and secondly on the way the kind is grown. Our problem therefore is already ceasing to be a simple one.

The rust question indeed becomes more complex the further we investigate it. In general, rust only becomes epidemic when some factor like long continued wet and cloudy weather favours infection and at the same time interferes with the normal growth of the crop. This, however, sometimes breaks down and cases occur when an epidemic takes place under conditions which favour neither the fungus nor the host. One of these occurred at Pusa in 1907. In that year, a large number of species and varieties of wheat were grown with the object of discovering a wheat immune to rust for breeding purposes. One was found—a variety of einkorn or one grained wheat. Einkorn grew with great luxuriance and vigour and entirely escaped the three common rusts at Pusa. As it had not flowered by the end of March and was growing vigorously while all other wheats were dried up by the heat, it was allowed to grow till the early rains in June to see if it would form ears during the hot months of April and May. Early in May, a severe epidemic of black rust occurred which lasted till the rains when the plot had to be ploughed up. This case is interesting as it was previously considered that the high temperatures of April and May were above the optimum not only for the wheat crop but also for the growth of

rust and for the germination of the spores. Nevertheless, a variety previously considered immune broke down completely under these conditions. There appears therefore to be no such thing as immunity to black rust. The amount of infection seems to depend on circumstances.

Green-fly.

The second example of disease I wish to consider is that caused by the common green-fly. This insect disease is very widespread and occurs on a large number of fruit trees and other plants all over the world. The life history is well known. The remedy is a simple one—spraying with some wash in which soft soap is one of the chief constituents. The spray suffocates the pest. At first sight, this appears to complete the subject and there seems nothing more to investigate. My experience, however, indicates that this disease is by no means so simple as it appears.

It is generally considered that the only cause of green-fly attacks is the insect itself. If this is so, there seems no reason why the pest should not spread rapidly in any garden after its first appearance in the spring. This was by no means the case in the Quetta fruit experiment station, where this pest has been under observation for some years. Frequently trees remained quite free from green-fly in the immediate neighbourhood of others badly affected. The disease did not spread as one would have expected. This happened year after year. It would appear, therefore, that something else besides the green-fly is necessary for successful infection to take place. The tree must be in a certain condition for infection to occur.

Some light has been thrown on the conditions necessary for green-fly attacks as the result of a number of irrigation experiments at Quetta. Following American experience on certain soils, an attempt was made to store up water in the subsoil during the winter and spring for use during the subsequent hot weather, when water is very scarce. The experiments were successful as far the saving of summer watering was concerned. Water was saved but at the expense of severe attacks of green-fly. All the plots without exception which were watered heavily in the winter were badly

attacked by green-fly the next spring. Those which had little or no winter irrigation escaped. Heavy winter watering had therefore to be given up. The cessation of this practice was at once followed by the recovery of the trees from green-fly attack.

Among the experiments which have been conducted on this subject, the following may be quoted :—

1. Four heavy winter irrigations were applied to three plots of peaches and one of nectarines during the winter of 1915-16. In all cases, the trees were very badly attacked by green-fly during April 1916, and the attack was much more severe than in the neighbouring gardens. Further watering was then stopped and the soil round the trees was broken up down to the upper roots. In this way soil aeration was restored, and after about a month the new growth produced was free from green-fly. The trees then presented a remarkable appearance. The first formed leaves on each twig showed extensive damage by the pest, the late formed leaves on the same branch were normal and perfectly healthy. Diseased and normal leaves were on the same branch and the pest did not spread.

2. The above four plots were treated in quite a different manner during the winter of 1916-17. After the summer, only one watering was given—on September 30th—and during the winter and spring no irrigation water at all was applied. As a result these plots were practically free from green-fly, the trees grew vigorously and the foliage showed all the characteristic appearances of healthy peach trees. These plots stood out in marked contrast to many of the trees to be seen in the Civil Station when in 1917 the ravages of green-fly were far above the average. By altering the method of irrigation, susceptible trees at once became resistant.

3. Three lines of almonds (a deep-rooted tree), and a plot composed largely of various stocks including plums, almonds and peaches, which were clean cultivated in 1916 and which were remarkably healthy and quite free from green-fly, were sown with Persian clover right up to the stems in August and September, 1916. Several waterings were applied to these trees during the winter and

spring. All the almonds, the seedling peaches, and some of the plum stocks became badly affected by green-fly soon after the leaves appeared at the end of March, 1917. By May, the attack was severe and practically all the young growth was affected. In this case, trees free from green-fly in 1916 lost in a single season all their immunity as a result of winter watering.

4. A number of almond and peach trees—grown under a system of furrow irrigation by which over-watering is almost impossible—were planted in the autumn of 1916 close to one of the lines of almonds which was over-watered during the winter. The object of this was to obtain another demonstration of the fact that insects like green-fly are unable to attack healthy plants. The over-watered trees were all affected by the pest which in no case spread to the plants which had been watered by furrows and which had obtained an abundant supply of air for their roots.

These results, which have been repeated on several occasions at Quetta, suggest that the cause of green-fly attacks is not the insect and that the control of the disease must be sought elsewhere than in the destruction of the pest. Green-fly does not seem to be able to attack a really healthy tree.

Red rot in sugarcane.

The last example of a disease involving a parasite I wish to refer to is the red rot of sugarcane. This is very common in certain areas of India, such as the black soil area of the Central Provinces, North Bihar and the Godavery delta where soil aeration difficulties are common. This fungus disease attacks the cane during the ripening period and leads to a great loss of sugar. Now when the varieties of sugarcane grown on the heavy black soils at Sindewahi were transferred by Dr. Clouston to the open, porous, well-aerated *bhata* soils at Chandkhuri in the Chhattisgarh Division, two remarkable facts were observed. In the first place, the sugarcane grew much faster on the poorer *bhata* than on the much richer black soil and yields of as much as 40 tons of stripped cane to the acre were obtained. In the second place, and this fact is of the greatest

interest, *there was a remarkable absence of the red rot fungus.* As is well known, the texture of black soils like those at Sindewahi is easily destroyed during a heavy monsoon. At Chandkhuri, on the other hand, a rainfall of 70 inches has no deleterious effect on the texture of *bhata.* On the black soil areas red rot is common, on *bhata* it is rare. These facts leave no doubt that in this disease of sugarcane there are other matters to consider besides the fungus.

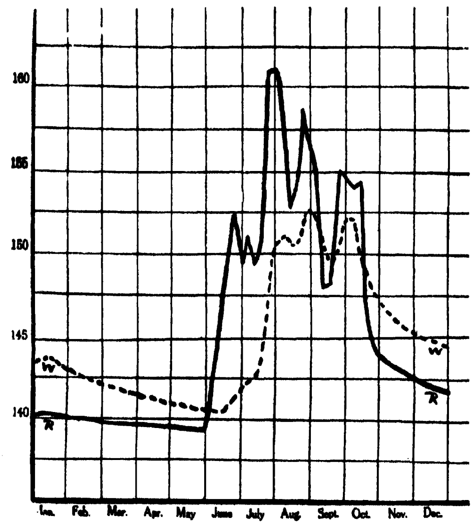
Why does the natural resistance of the plant to fungi like rust and red rot or to an insect like green-fly break down ? We have seen that under certain circumstances at Pusa, einkorn is unaffected by rust even *when surrounded by plants heavily infected.* Sugarcane escapes red rot at Chandkhuri on the porous, well-aerated *bhata* soils. In a similar manner some of the almond trees at Quetta resisted green-fly when separated by only a few feet from trees badly attacked. When the conditions of growth in these cases are altered, the natural resistance disappears and infection takes place. Why is this ? One possible explanation is the following. Normally the protoplasm in the green cells of the leaves of healthy varieties is strong enough to resist the inroads of a fungus or of an insect. The healthy plant protects itself. If, however, soil conditions alter, then root damage is likely to occur and with this it is not difficult for the acid products of decay to enter the sap current and gradually to lower the resistance of the protoplasm of the green cells. A time comes when infection is just possible, then when it is easy and finally when it is exceedingly rapid. We shall probably get further light on susceptibility, resistance and immunity by the detailed investigation of the cell sap during the growth of the host plant. At first sight, wheat rust, red rot and green-fly seemed very simple questions. Even in this brief consideration of the subject they have passed into the domain of experimental physiology.

Wilt diseases in Bihar.

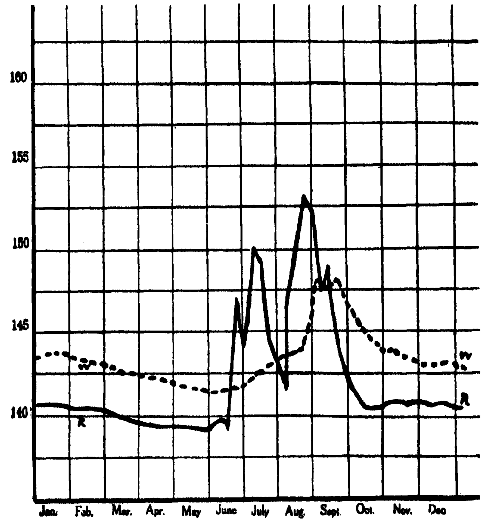
Up to this point three diseases have been considered in which either a fungus or an insect is involved. I now pass to

PLATE XXXV.

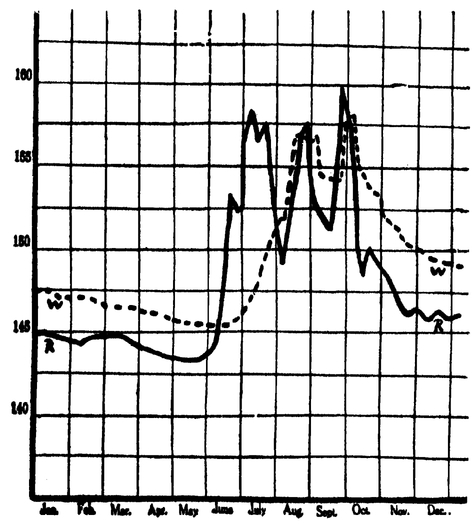
1910



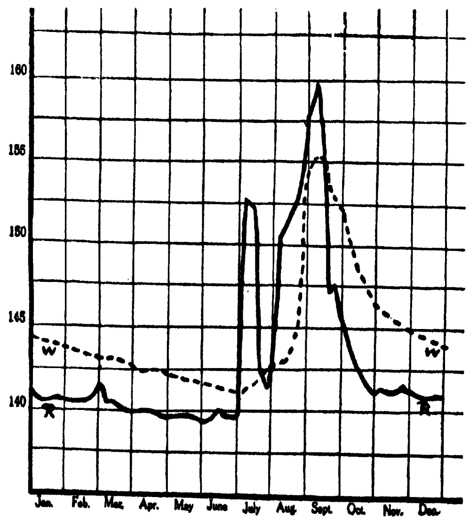
1912



1913



1914



CHANGES IN THE RIVER AND WELL LEVELS AT PUSA.

The well levels shown by dotted lines. The observations are expressed in feet above mean sea level.

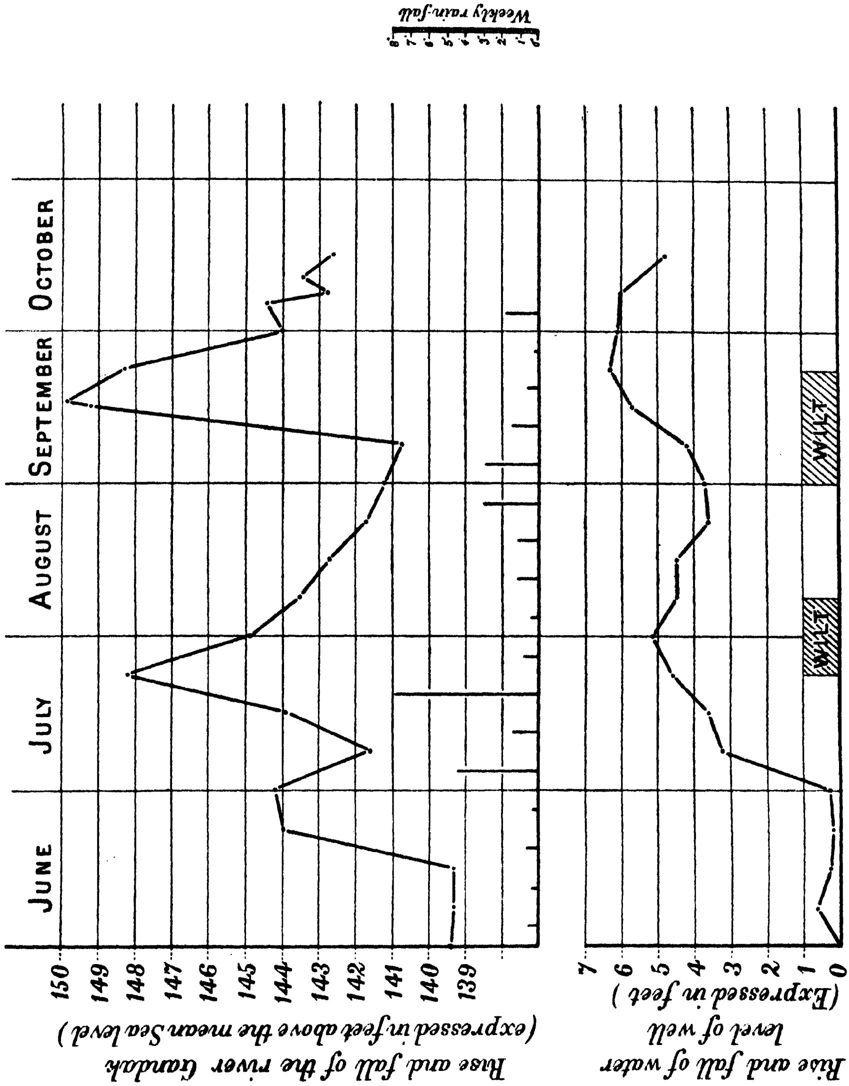
a group of wilt diseases met with on the alluvium during the second half of the monsoon in which insects and fungi are of little or no importance. Several crops are affected of which Java indigo, *sanai* (*Crotalaria juncea* L.) and *patwa* (*Hibiscus cannabinus* L.) have been studied in some detail in the Botanical Area at Pusa.

Java indigo (*Indigofera arrecta* Hochst.), the species now generally cultivated in Bihar, frequently suffers from wilt during the late rains. At the beginning of the monsoon, growth is normal but in wet years a change takes place about mid-July in the character of the foliage while the rate of growth slows down. The leaves alter in appearance, assume a yellowish green, slaty colour, become reduced in size and show extensive longitudinal folding. With this alteration in the foliage, leaf fall is rapid until only stunted tufts of leaves at the ends of the branches remain. In severe cases, this is followed by the death of the plant, the process taking place slowly, a branch at a time. The external symptoms of wilt suggest extensive root damage which is confirmed by exposing the root system by means of a knapsack sprayer. Wilted plants are found to possess very few fine roots and nodules in an active condition. The main taproot and the laterals are alive and normal but the fine roots are mostly dead or discoloured and the number of absorbing root hairs is exceedingly small. The destruction of the active root-system, including the nodules, takes place from below upwards. When wilt is well established, the absorbing roots still alive are all in the upper two or three inches of soil. Evidently some factor is in operation which destroys the fine roots in the subsoil and which afterwards affects those towards the surface.

The first thing to do was to discover the factor which injuriously influences root development during the late rains. This was soon found. It was nothing more than the interference with the general drainage which follows the rise of the subsoil water in July. Drainage stops in North Bihar when the rivers have too much rain to deal with. The movements of the river levels and the general ground water in this tract are illustrated by the curves

(Plate XXXV) which represent the state of affairs of the river at Pusa and of one of the wells (about a quarter of a mile distant) for the years 1910, 1912, 1913 and 1914. These curves are typical of the subsoil water conditions of North Bihar during the rains. In years of normal rainfall, when the rivers and the ground water remain at a high level for some weeks, indigo wilt is the rule. On the other hand, if the level of the wells remains low and if the rainfall is moderate, the amount of wilt is negligible. There is a distinct connection between the occurrence of wilt and the position of the ground water level, or in other words between wilt and drainage. If we examine the matter in greater detail, we find this connection is exceedingly close. In 1919, a year when the rainfall was below the average and the movement of the ground water was slight, the relation of wilt to drainage was, nevertheless, quite distinct. In that year, wilt was almost negligible and only made its appearance at Pusa on two occasions, between July 23rd and August 7th and again between September 1st and 23rd. A reference to Plate XXXVI will show that these attacks followed a rise of the ground water combined with heavy rain. They passed off when the ground water fell and drainage was resumed. These results suggested that wilt is due to bad drainage rather than to a deficiency in available phosphate as has been suggested. To settle the point definitely, a series of experiments was carried out in lysimeters, one thousandth part of an acre in area and about 4′ 6″ high. These are really large square flower pots either cemented or made of porous bricks with drainage openings at the base which can be opened or closed at will. Two kinds of soil were used in these experiments, Pusa soil which is said to be low in available phosphate and similar alluvial soil from Kalianpur near Cawnpore which is exceedingly rich in available phosphate. When analysed by the ordinary method, Kalianpur soil contains about 300 times more available phosphate than Pusa soil. Indigo was grown in several series of these lysimeters in both kinds of soil. Now these large flower pots are above the ground level and are provided with drainage openings which are quite independent of the general drainage of the country. Any factors due

PLATE XXXVI.



RISE AND FALL OF THE RIVER AND WELL LEVELS AT PUSA IN 1919.

to the rise of the ground water cannot therefore operate. We can however imitate the general soil conditions by closing the openings and by allowing the lysimeters to waterlog from below. The results obtained in these experiments are significant. They can be shortly summed up as follows :—

(*a*) In both Pusa and Kalianpur soil, the indigo in the lysimeters with free drainage escaped wilt altogether.

(*b*) When the drainage openings were closed and water-logging from below took place, all the plants in both kinds of soil were wilted.

(*c*) The amount of wilt in the Kalianpur soil (rich in available phosphate) was much worse than in Pusa soil (low in available phosphate).

(*d*) The growth in Kalianpur soil was much slower than in Pusa soil.

These results suggest that there is nothing wrong with the Pusa soil as such during the second half of the monsoon if drainage is provided. The amount of available phosphate has nothing to do with wilt. They, however, strengthen the view that the factor responsible for the disease is the rise of subsoil water and the prevention of drainage. This has been confirmed by a large amount of work carried out on the root-system of Java indigo under various conditions the results of which are published in one of the recent Pusa Memoirs (Botanical Series, vol. XI, no. 1, 1920). The details are too long and too complex for this lecture. The really interesting point in this investigation is that the cause of the wilt disease was found after a study of the movements of the level of the river and of the wells and of the relation between the altered soil factors so produced and root development.

Of equal interest is the wilt of *patwa* (*Hibiscus cannabinus* L.) known in the Central Provinces as *ambari*. The details closely follow those already described in the case of Java indigo. The severity of wilt in this crop was found to vary with the type of plant. Those with deep root-systems were badly affected, those with the laterals near the surface suffered much less. The root-system of a shallow and deep rooting type are shown in Fig. 1. Side by side a closely related species of *Hibiscus*—*H. Sabdariffa* or Roselle—was

found to escape wilt altogether at Pusa even in the wettest years. Its immunity to wilt appears to be largely due to the character of

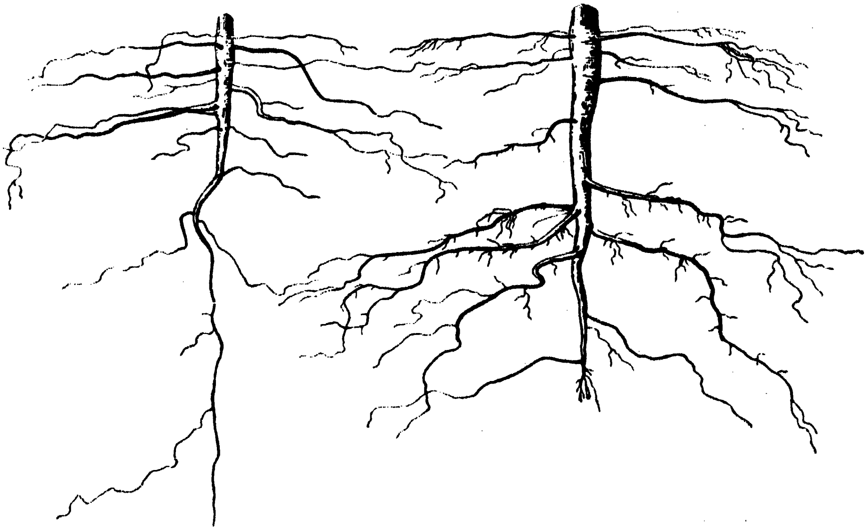


Fig. 1. Early (left) and late (right) types of root-systems in *H. cannabinus.*

its root-system which is exceedingly superficial compared with that of *ambari* (Fig. 2).

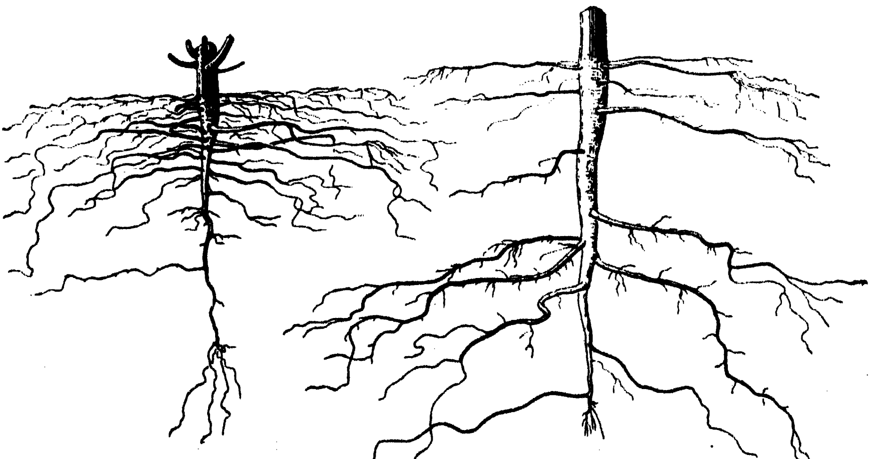


Fig. 2. The root-system of *Hibiscus Sabdariffa* (left) and *H. cannabinus* (right).

I have referred to these cases of wilt in order to show how important it is in studying disease to ascertain the general facts of

root development and particularly those of susceptible and resistant varieties. Ordinarily we only see half the crop—the portion above the ground—and pay far too little attention to the root-system and to its relation with the soil. We are too much inclined to draw conclusions from what can be seen of the crop above the ground and to take no pains to ascertain what is happening down below. We should condemn a judge who gave a verdict after hearing only a portion of the evidence. We often accept results of experiments on crops and on crop diseases equally imperfect. The remedy is obviously a wider outlook in research. I suggest that our knowledge of disease will be advanced by investigation in two directions: (1) by the detailed examination of the root-system of varieties and the relation of the roots to soil factors like water supply and aeration and (2) by the examination of the cell sap of susceptible, resistant and immune varieties of crops throughout the period of their growth. Such investigations are certain to extend our knowledge and might easily influence practice.

This leads me to a larger question—the paramount necessity of basing all agricultural improvements on a deep and wide study of the question or, in other words, on the work of research. The public in India comes in contact with the Agricultural Department through its organization in the districts where it receives improved seed, new crops, better implements and practical instruction in their use. In many respects the organization of agricultural work in the districts in India is in advance of anything to be found in other parts of the Empire. In this result both the Agricultural Department and the Government of this Province have played an important part. This success in organization must however not blind us to the fact that all this assistance to the cultivator depends on much patient research in the fields and laboratories of the Experimental Stations. There are two sides to the work—research and organization. We must never forget that research is essential in providing a constant flow of practical results for the benefit of the people.

AN OUTBREAK OF ANTHRAX AT HISSAR.

BY

R. BRANFORD, M.R.C.V.S.,

Superintendent, Government Cattle Farm, Hissar.

My excuse for this note is the fact that since the Civil Veterinary Department took over charge of the Government Cattle Farm, Hissar, on 1st April, 1899, no case of anthrax was diagnosed till 1920.

On the farm, as a routine procedure, all animals which die undergo post-mortem examination. Rare exceptions to this rule are :—

1. Animals which die on the grazing grounds, and are eaten by jackals, etc., before discovery.
2. Animals which die in the hot weather at a distance from head-quarters, and become too putrid for examination before it can be made.

As a rule, however, post-mortems are made, and as a rule the cause of death is ascertained. Occasionally post-mortems are made by inexperienced veterinary assistants, but the probability of failure to diagnose a case of anthrax on such occasions is ruled out by the fact that the post-mortem man himself, who has had great experience, is, as I found out as soon as this outbreak began, perfectly acquainted with the post-mortem features of the disease.

In fact, in face of the actual outbreak, it was obvious that although an isolated case might have occurred without its being diagnosed, nothing in the shape of an outbreak can possibly have occurred since 1899. An outbreak must have been detected. Records of disease on this farm prior to 1899 are scanty, and

generally not available. However, I gathered from old members of the staff that a very severe outbreak occurred in 1895. Some 300 cows are said then to have died of the disease, mostly at Sully, which is situated in the *bir* some five miles from Hissar and consists of a group of eight lines for cows.

The outbreak in 1920 was also mainly confined to cows at Sully, although the first few cases detected died in the home farm at Hissar. The first was a cow which died on the 1st of October, 1920. I did not then connect the disease with Sully at all, but the cow had been sent in from Sully, owing to her being heavy in calf, a few days before she died. The next cases were two ewe lambs: one died on the 18th and the other on the 20th November. Presumably they were infected from the above cow; neither had ever been within four miles of Sully.

The next case was a cow which died on the 29th of November; she also had been sent in from Sully to calve, and had been in the home farm a few days only. During December and January, 22 more cows died of the disease: 17 at Sully and 5 in the home farm, the home farm cases all being recent arrivals from Sully. On January 20th, 350 cows with calves at heel were moved from Sully to lines at Stables about half a mile from the home farm. Four of these cows died of anthrax after removal: one on the 22nd, one on the 27th and two on the 30th January. I think they were all infected at Sully. A curious point in connection with the disease at Sully was that it was confined to one side of the lines. The lines are situated as in the diagram below:—

Cows *No.* 4	Cows *No.* 5
Cows *No.* 3	Bulls *No.* 6
Cows *No.* 2	Cows with calves *No.* 7
Cow *No.*	Cows with calves *No.* 8

The cases at Sully were confined to cows in Nos. 1, 2, 3 and 4. The cases at Stables, however, were in cows which came from lines Nos. 7 and 8. A bull in No. 6 which had been running at night with cows in No. 2 became ill on December 15th, probably from anthrax. He recovered.

MEASURES TAKEN TO CONTROL THE OUTBREAK.

As is the custom on the farm in cases of contagious disease, the first few cases were burnt. Burning large carcases, however, in my experience is difficult to carry out properly, and uses up a great deal of fuel of which there is always a shortage here. As the outbreak developed, carcases were buried in a disused dry well. The well was about 60 feet deep.

The places where the bodies of dead cows were found were spread over with dry fuel and burnt. All possible precautions were taken as regards disinfecting discharges from natural orifices, etc. In the home farm disinfecting operations, etc., were carried out under adequate supervision and appear to have been successful. No animal, except the two sheep mentioned above as probably infected from the first case, became infected there.

As the outbreak developed, herds of cows in which a case of anthrax occurred were next day inoculated with serum supplied by the Muktesar laboratory. The serum appeared to protect well for three weeks or so. However, several cases occurred in inoculated animals a month or more after inoculation and one or two herds were re-inoculated.

SOURCE OF INFECTION.

I was never definitely able to trace the source. There are a number of highways through the farm grazing grounds. The most frequented one passes through Sully. There were unusually large movements of outside cattle through these roads in September and October owing to the approaching fodder famine. These animals may have imported the disease although I have no record of any travelling animal having died in the *bir*. This is, however, not

definite evidence that none died, as a carcase will be almost completely removed by jackals and vultures in an hour or two.

The fact that both the 1895 and 1920 outbreaks of anthrax were in cows and mainly at Sully suggests some connection between the two. However, if the 1920 outbreak was started by spores from the 1895 one, it is difficult to account for the absence of outbreaks during the interval, cows having been kept at Sully under the same conditions all the time. It is true that 1920 was a year of bad rains, that the cattle were grazing close to the ground, and down into holes and depressions, where in ordinary years they do not go; but Hissar is a district where rain failure is common, and fodder famines more or less occur every 3 or 4 years.

VIRULENCE.

Most of the above cases were found dead, no symptoms having been noticed prior to death. In a few cases, however, cows were noticed to be off feed and dull so long as 24 hours before death. One case, the bull mentioned above, recovered. He was a seven years old bull in fat condition. He was off his feed on the 15th, had a dry nose, and the appearance of fever, but was chewing his cud. On the 16th and 17th he remained off feed, was very constipated, and did not chew his cud. He was given 2 lb. of magnesium sulphate on the 17th. On the 19th he was markedly worse: his nose was very dry, he was sluggish, and disinclined to get up. He was better on the 20th, and on the 21st fed well and made a rapid recovery. During the five days he was sick, he lost condition very rapidly.

Cows on this farm are, speaking generally, never handled, except a few which are milked. Taking of temperature is therefore not an easy matter. They generally have to be lassoed and thrown before their temperature can be taken. Hence I was never able to take the temperature of the herds in which cases occurred. One or two cows which were noticed to be dull however did not die. I suspect a percentage became attacked and recovered. There were some 350 calves under their mothers in contact; up to the time of writing (27th May, 1921) no calf has died of anthrax. In one case a smear was taken while a cow was still alive, the cow

dying some 30 minutes after. Anthrax bacilli swarmed in the smear.

CONCLUSIONS.

Serum alone is an unsatisfactory method of dealing with anthrax, unless one is able at the same time to discover and destroy all possible sources of infection. It is especially unsatisfactory on this farm where the majority of the cattle are wild and actively resent inoculation and still more re-inoculation.

Vaccine at present is not issued by the Muktesar laboratory. The history of vaccination for anthrax is not very encouraging, but it might be worth a trial.

Desiccation and heat do not appear to have much effect on the virus. Since 4th August, 1920, to date (27th May, 1921), the total rainfall here has been $\frac{1}{10}$th of an inch and the shade temperature has risen to 115°F. Three more cases of anthrax, however, have recently occurred from same Sully herds as before.

Conditions most likely to cause a cessation of the disease are probably sufficient rain to cause enough grass for grazing again.

POSSIBILITIES OF MUSHROOM INDUSTRY IN INDIA BY CULTIVATION.

BY

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MUSHROOMS are common in many places of India. They grow abundantly during the rainy season and are eaten by villagers of different parts of India. They are sold during the rainy season in some local markets of Calcutta, Bankura, Deoghar, Punjab, Kashmir, Burma, etc. In Calcutta, during the rainy season, there is an abundant supply of these from suburbs in the New Market, the Bow Bazar and the College Street Markets and " Natun Bazar," and they command a ready sale. They form a favourite dish with certain classes of people here. At present there is no regular cultivation of edible mushrooms in India. They are mere chance products of the rainy season.

I have collected the common edible varieties of Bengal mushrooms. They are mostly *Volvaria terastius* B. & Br., *Lepiota albuminosa* Berk., *Lepiota mastoides* Fr., *Agaricus campestris* Linn., and some small puff-balls (Gasteromycetes) from Bankura ; the full description of *Volvaria terastius* and *Lepiota mastoides* I have published with plates in " The Proceedings of the Science Convention of the Indian Association for Cultivation of Science for 1918 ", pages 136-137 ; and the description of *Lepiota albuminosa* (*Collybia albuminosa* Petch) with plate came out in " The Journal of the Asiatic Society of Bengal," vol. XVI, no. 8, p. 349. Mr. McRae has published a description of *Agaricus campestris* (*Agri. Jour. India*,

vol. V, pt. III, p. 197). The present article embodies the result of further enquiries on the subject.

I have had some of these fungi subjected to chemical analyses by Mr. C. B. Roy, Demonstrator of Chemical Physiology at the Calcutta Medical College, to whom my sincere thanks are due. From the following table of analysis, it will appear that some of them are even superior to the English mushroom (*Agaricus campestris*):—

Local edible varieties.

	Protein	Carbo-hydrates	Fats (ether extractives)	Ash	Moisture
	Per cent.		Per cent.		
Volvaria terastius	2·28	Trace	0·18	..	Analysed in dried condition.
		Per cent.			
Collybia albuminosa	12·8	14·8	Trace	..	Analysed in dried condition.
			Per cent.		
Agaricus campestris	2·736	1·6	0·37	0·15	95·2 per cent.
Puff-balls (Gasteromycetes from Bankura)	2·2	1·35	0·56	9·16	93·85 ,,

English edible mushroom (Agaricus campestris) *according to G. Massee.*

Agaricus campestris	0·18	0·46	0·03	..	..

American edible mushroom, U. S. Dept. Agri. Bull. No. 79.

Agaricus campestris	2·25	4·95	0·20	..	91·30

Our *Collybia albuminosa* (*Lepiota albuminosa*), which is called in local vernacular "Durga Chhatu" (appearing in September-October, usually during the time of the Durga Puja ceremony), is much richer than others.

Following Duggar's method of tissue-culture, I have been successful in artificial culture of two of the Agarics, *Panæolus cyanascenus* B. & Br. and *Coprinus niveus* Fr., in sterilized dung medium. The details of the method have been published in "The Proceedings of the Seventh Indian Science Congress held at Nagpur in 1920." This tissue-culture method in sterilized dung medium is highly successful in America in the rapid development of the mushroom industry in recent years. Following this tissue-culture method, artificial culture of these local edible Agarics is now being attempted in my laboratory. The results of the experiments will soon be communicated at a later date. My object is to make our own spawn, so that the production of mushrooms might become a matter of certainty and that in future mushroom growing might become a special industry in India as it has been in America since 1913-14.

In 1908 there was a thorough and searching enquiry instituted by Sir David Prain, Director of the Kew Gardens, London, through the Department of Revenue and Agriculture, Government of India, about the edible mushrooms from all parts of India. It attracted his attention as it was used as famine food in different parts of India, especially among the poor during the famine of 1896-97 (*Ind. Forester*, Feb. 1908, p. 20, Appendix). The results of the enquiry have been embodied in the records of the Indian Museum (Economic Botany Section), from which it can be gathered that there is a ready market for edible mushroom in Burma, Punjab, Kashmir and Afghanistan, provided there is a regular cultivation of it. To the Burmans it offers a favourite dish and they pay as much as 12 annas for each mushroom.

The following extract from "The Indian Agriculturist," April 3, 1886, is not without interest :—"The delicate appearance of some of the edible fungi has from time immemorial tempted man to use them as articles of food. As it is always difficult to distinguish the poisonous from the edible varieties, the Sastras have enjoined a wholesale prohibition of the use of these ephemeral esculents. Nevertheless the use of mushrooms as an article of food is as old as Manu the lawgiver. It is still used extensively in the dry regions

of Bengal, and also in the valley of Kashmir. The varieties known in Bengal are the following :—

1. Phudki-Chhatu (the small and the large).
2. Puwal-Chhatu.
3. Kadan-Chhatu.
*4. Durga-Chhatu.
5. Urji-Chhatu.
6. Kud-Kudi-Chhatu.
*7. Kat-Chhatu.
*8. Govar-Chhatu.
9. Indu-Chhatu.
10. Pachan-Chhatu.
*11. Kondka-Chhatu.
12. Gundura-Chhatu.

"Of these, those which are marked with an asterisk, *i.e.*, Nos. 4, 7, 8, and 11, are considered unfit for food. None of the abovenamed 12 varieties of truffles and mushrooms are cultivated in Bengal. Indeed, the cultivation of these ephemeral vegetable growths is unknown. Some, however, attempt to raise a few poor specimens of the second variety, Puwal-Chhatu, by allowing waste paddy straw to rot in a heap, and depending on chance for the germination of these fungi. It is not known to the cultivators of Lower Bengal that these esculents may be reproduced by their spawns. Of all these varieties, Urji-Chhatu is considered as the most delicate in flavour. They are found generally under ant hills or *dhipis* as they are called. In the Bankura and Birbhum Districts, these are collected by the low-caste dwellers of the forest, known as Buno, and sold to the villagers in exchange for rice, tobacco or salt. A kind of *polao* is made with these fungi, and I must acknowledge that they are not at all inferior to *polao* made with meat. In the Kashmir Valley the *guchha* is much used. This fungus has the closest resemblance to the truffles of Europe. It is sold in the Kashmir shops in a dry state, and older the article the greater is its value. The Kashmirians seem to be aware of the fact that the objectionable properties of fungi are minimized by keeping."

Mr. A. Hansen says in "The Scientific American," dated 14th April, 1917, p. 370 :—"A broader knowledge and more intimate acquaintance with the mushrooms will do much to solve the high cost of living problem. Many millions of these sources of delicious foods annually go to waste in our woods and fields because of lack of knowledge regarding their utility. The mushrooms are not only nourishing but in addition offer a variety to our daily diet, that is

excellent, cheap and satisfying. They could and should be eaten far more generally than they are at present."

In these days of scarcity of food and the enormous rise of prices of fish and of the rarity of vegetables during the rainy season, if the Indian mushrooms can be introduced as a daily article of food, it may do something to solve the high cost of living problem and mushroom-growing might become a special industry in India.

Of course for its introduction as a daily article of food amongst the common people here, who are very conservative, it requires a good deal of propaganda work amongst them. I think the Agricultural Department of the Government of India, with the district agricultural demonstration farms at their back, can easily effect it, if it is taken up in earnest; and it cannot be denied that it comes within their province, as it will lead to the economic development of the country by cultivation.

Selected Articles

"RURAL BIAS" IN SECONDARY SCHOOLS.*

THE WORK AT SEXEY'S FOUNDATION SCHOOL IN SOMERSET.

BY

S. L. BENSUSAN.

At first sight there is little remarkable about Sexey's Foundation School. The buildings that compose it are perhaps more than ordinarily attractive and certainly the situation is quite out of the common. Sexey's stands rather high on land overlooked from a distance by the Quantocks, the Mendips and the famous Dunkery Beacon. From the upper rooms of the school house one can glimpse the islands of the Severn Sea. The school itself is remote from all great centres of life and action, though within touch of places boasting the most interesting associations. Cheddar is some five miles away, Glastonbury ten, Wells about as far, and the first thought that strikes the casual visitor is that those who teach and those who are taught must admit that their lines are cast in pleasant places. But Sexey's could hardly claim the attention of agriculturists if it were merely an attractive and well-placed secondary school; the special interest lies in the fact that it is one of the few centres in England in which secondary education is associated with what is known as a "rural bias."

There are many agriculturists in this country who feel very strongly that the development of husbandry would be furthered considerably if secondary education took more note of our greatest

* Reprinted from *Jour. Min. Agri.*, XXVIII. no. 2.

national industry. They would like to see children who have a natural aptitude for land work encouraged to develop rather than forced to suppress it, and they believe that there is no more important problem before statesmen to-day than the repopulation of rural areas, with the great resultant stimulus to the production of home-grown food. They feel that while in the old days the training that the boy or girl of farmer or farm labourer received was adequate to the demands that the future would make, the conditions have been altered entirely by the development of scientific investigation, by the advent of machinery, by the acquisition of precise knowledge and above all by the pressure of the economic situation. The State has recognized that pressure; it is spending considerable sums of money in the quickening of sound production, and consequently it is of first importance that there should be an ever-lengthening procession through our secondary schools of boys and girls bent upon acquiring the special knowledge that will enable them to take advantage of modern conditions. The Board of Education is not unmindful of the new needs that the past few years have brought into being, and while expert opinion there is convinced that, if it is to be effective, secondary education must be an all round education and not limited in scope or purpose, yet certain concessions have been found possible. Provided that the curriculum of a secondary school embraces a modern language, some science and English, the "rural bias" is recognized and even encouraged. The new development is at present only in its first stage, and Sexey's is one of four secondary schools in which the "rural bias" may be seen in the working. Welshpool County School for boys is another, Knaresborough Rural Secondary School in the West Riding is a third, and the Dauntsey Agricultural School at West Lavington in Wilts the fourth. In three years at Knaresborough thirty per cent. of the boys went on to farms, while others took to surveying or garden work or emigrated to the Dominions. At Welshpool out of 250 boys more than thirty per cent. went on to farm work or took up estate office work and surveying. At Sexey's where the majority of the pupils are associated directly or indirectly with agriculture the proportion that seeks a living from it is larger still.

Sexey's differs from Knaresborough and Welshpool in so far as it is a co-educational school, the boys and girls working in the same classrooms to a like end. While it is a secondary school by virtue of its four-year course for children who may come in at the age of twelve, there is a preparatory side for boys and girls, so that it is possible for a child whose training and associations suggest the possible development of an agricultural bias to start at Sexey's and receive complete education there.

The support received for this farm, which is of course a branch of the school and was a subsequent addition to it, comes from many sources.

The original foundation was the Manor of Blackford, left by Hugh Sexey, Auditor to Queen Elizabeth and James I, for educational and other purposes in the year 1617. Out of funds provided by this foundation a school was built, and when the Rev. Edward Smith, who had been Instructor in Agriculture under the Wiltshire County Council, was asked to take charge of it, his keen interest in farming led him to consider the question of establishing a training farm within easy reach. A stone's throw of the school there was a small holding of some twenty acres or so, derelict for many years, the rich land gone to waste, the little farmhouse boarded up. It should be remembered that this was more than twenty years ago when agriculture was at a very low ebb and even those who farmed the rich Somersetshire land were hard pressed to make a living. Mr. Smith was of opinion that the possibilities of improvisation if grasped by boys and girls who have a natural instinct for land work, would provide them with a key that would open many a door through which, in normal times, only those could hope to pass who are plentifully supplied with the world's goods. He acquired the derelict holding, and being a skilled practical man with quick eye and trained hand, he managed to convert the farmhouse into a farm school at the trifling expense of £150. Those who have any working acquaintance with the present cost of adaptation will be astonished to realize how much could be done with a very little so recently as twenty years ago. The ground floor of the farm has been divided up into a dairy, a cheese-making room, a cheese-store for ripening and

an incubator house. Beyond these there is a workshop, a milking byre, a pigs' kitchen and a cider house. On the upper floor there is a delightful little classroom with well equipped agricultural library, and there are other rooms for the study of methods of fruit storage and for demonstrations in seed ripening and apiary work. Beyond the farm there is one outhouse that has been supplied with power for the economic handling of every farm product and its adequate preparation as food for stock. The mixing floor is concreted and the motor is driven by electricity supplied from Wedmore a mile or so away. There is a cow house and an up-to-date poultry station, and there are piggeries.

A special and notable feature of this small farm is that the actual work is not done by the pupils. Mr. Smith holds very strong views on this matter, and is of opinion that it is not right to ask any of his boys or girls to do work that should command payment. Yet although the total grant-in-aid of the farm school is limited to about £200 a year—a grant from the Board of Education, the regular grant to Secondary Schools, and school fees—the farm maintains three men at the standard wage and supplies the school, with its 150 pupils and resident staff of nearly a dozen people, with all the fruit, vegetables, eggs, milk, butter and bacon consumed.

The great difficulty that the school has had to face on its farm side is the postponement of the operation of those provisions of the Act of 1918 by which parents were compelled to keep their children at school until the age of 16. The training at Sexey's being thoroughly practical and modern, attempts have been made by parents who are working farmers to withdraw their boys and girls before they have completed their course, because they find that after a couple of years or less in the farm school they can replace a skilled man.

Mr. Smith finds as a result of his long experience that in addition to giving the main school "rural bias" the foundation of the farm school serves to provide fitting occupation for those boys and girls on whom a purely academic training would be wasted, while affording opportunities to those who show a special aptitude and wish to travel beyond the boundaries of ordinary farm work to prepare for an

agricultural college. Pupils come from all parts—from local elementary and private schools, from secondary schools, and in some cases from the Continent. Perhaps because Mr. Smith is a very keen botanist, botany is the foundation of much of the outdoor practical work of the farm, theoretical and practical, before the farm school can be reached.

Naturally all demonstrations are carried out on a small scale, but it is abundantly clear that effectiveness is not a matter of acreage. There is a quarter of an acre of garden land kept under every variety of seasonal crop, so that the sequence of the market-gardener's work can be followed. There are green-houses; there are cool and heated frames. In addition to delightful orchards there is half an acre of fruit garden in which fruit culture is taught in all its branches—grafting, budding, transplanting and the rest—while owing to the rich soil and the mild climate, transplanting work is carried on under conditions that must excite envy among those who have learned their orcharding on colder and less grateful lands.

The farm work itself embraces nearly all the problems that agriculturists must consider. For example, to take mangold cultivation, there is a plot some 110 yds. long and 11 yds. wide divided into three strips. One is manured with superphosphate at the rate of 4 cwt. per acre, sulphate of potash $\frac{1}{2}$ cwt., nitrate of soda 1 cwt., salt 3 cwt. On the next plot the rates are superphosphate 6 cwt., sulphate of potash $\frac{3}{4}$ cwt., nitrate of soda $1\frac{1}{2}$ cwt. On the third the rates are: superphosphate 8 cwt., sulphate of potash $1\frac{1}{4}$ cwt., nitrate of soda 2 cwt., salt 3 cwt., and beyond these three plots there is a little triangular piece on which mangolds are being grown without manure. A quarter acre plot of grass land has been divided up, all having been dressed with potassic superphosphate at the rate of 6 cwt. per acre, while half has received in addition nitrate of soda at the rate of 1 cwt. per acre. The manurial value of each is carefully explained and the pupils can compare for themselves the actual results obtained. Elsewhere swedes are being grown on plots with farmyard manure applied at the rate of 25 tons per acre over the whole, while one half has an addition of superphosphate, potash and sulphate of ammonia, and the other has superphosphate, potash

and nitrate of soda instead. Potatoes are grown under a variety of conditions. One plot has farmyard manure at the rate of 15 tons to the acre and is then divided up, one half receiving an addition of superphosphate, potash and sulphate of ammonia, the other superphosphate, potash and nitrate of soda, this additional manuring being the same as is given to the swedes. In addition to this there is another potato plot divided into five parts. The first has no manure at all; the second has superphosphate; the third superphosphate and potash; the fourth superphosphate, potash and nitrate of soda; the fifth superphosphate and nitrate of soda but no potash. Here, too, the pupils will be able to see for themselves the effect upon the yield of crop. The use of machinery and its value on the farm have not been forgotten and the necessary attention is given to farm book-keeping, farm correspondence and costs.

The ordinary course in agricultural science is open to boys and girls of the school between the ages of 15 and 17 who have reached the fifth form or can give evidence of having received public secondary school education up to the fifth form of the school from which they have come. In addition to farm book-keeping based on the year's accounts of the school farm, the course of study includes land measurement and surveying, the theory and practice of dairying—including laboratory practice, the use of the Gerber tester, the clean production of milk, the making of butter and cheese, the feeding and care of live stock, including the preparation of rations on a scientific basis—and the principles of land cultivation and manuring on grass land, arable and moor.

The Somersetshire orchards are unfortunately more remarkable for their beauty than for the state of their preservation, and a spirited effort is being made at Sexey's to teach students the value of pruning, spraying and a general clean up of dirty trees. In order to make the lesson memorable, some trees are cared for and others are left alone, so that the comparison is clear and obvious. Cider making is also undertaken by pupils, and in the laboratory they carry out qualitative analyses of feeding stuffs, manures and milk. The principles of drainage and elementary physiology are included in the curriculum, and practical demonstrations in bee-keeping are part

of the summer term's work. The course for girls includes all branches of dairy work, book-keeping, correspondence, poultry-keeping and a study of foods and feeding, together with practical gardening, fruit culture, fruit storage and preservation. Pupils have taken county agricultural scholarships, both senior and junior, and some have found high places in agricultural colleges and elsewhere. The practical work is associated with frequent lectures so that those who learn may understand the principles underlying their teaching.

By reason of the Government grant for secondary schools and with the aid of the county authorities, the Board of Education and Sexey's Foundation, it is found possible even in these days of high prices to charge the parents of boarders no more than £42 a year for board, lodging and books. Moreover—and this perhaps is one of the most important aspects of the whole undertaking—the terms under which the school is conducted provide that 25 per cent. of the admissions in any year must be free of charge, and this has a particular significance in view of the "rural bias" because it means that for every hundred pupils who can pay there must be the fixed proportion of those who are unable to do so. Here is the chance for the child of the agricultural labourer. It is not sufficient to give the agricultural labourer the minimum wage, because it leaves him without prospects and he sees no better future for his children than that of the so-called "unskilled worker." He wants something better, and here in the remote Somersetshire County he finds what he needs. At the present time 40 per cent. of the children at Sexey's are not paying pupils.

It is interesting to note that Sexey's School started in a barn and was not housed in its present attractive quarters until the success of the undertaking had been proved beyond all question. The Farm School was added to the premises as a going concern about the year 1913, when Mr. Smith handed over the buildings to the school authorities. To-day the full limit of the accommodation has been reached, and so great is the school's popularity that vehicles ply daily between Cheddar and Blackford to take pupils to and from the railway station.

It does not require any special gift of vision to see in the secondary schools with a "rural bias," of which Sexey's is so pleasing an example, a prospect that may go far to change the outlook of those who work on the land. It is admitted on all sides that no class of our population has done better work for the country or has received less return for it in years past than the agricultural labourer. The war brought these truths home to the community at large, and the worst of the farm labourer's disabilities have been removed by the Agricultural Wages Board and the Agriculture Act, while Village Clubs and Women's Institutes have developed the social side of rural life with the very happiest results. But this is not enough. The agricultural labourer's children have a right to be prepared to help the community at large by the development of their natural aptitudes along the most familiar lines. Welshpool, Dauntsey's, Knaresborough and Sexey's may constitute a small beginning, but as the knowledge of these undertakings grows and the value is recognized by the community it is not too much to hope that we shall see the "rural bias" a feature of secondary schools in all suitable districts, and that year by year they will send out a steadily increasing number of skilled workers on to the land. The expense is trifling; the reward is great; and in giving every encouragement to such a movement as this, the State will be recognizing in very practical fashion its debt to those who have raised a considerable part of the nation's food in most disheartening conditions for many years. The rising generation should prove capable, in the new circumstances that will follow, of increasing the output to a point at which we shall stand far nearer self-support, and the security that attends it, than we are to-day.

RESEARCH IN ANIMAL BREEDING.*

II.

BY

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In the first article of this series, published in the September (1921) *issue of the Journal, Prof. Punnett dealt with coat colours in cattle as an illustration of simple Mendelian inheritance.*

IN the case selected for illustrating simple Mendelian inheritance, *viz.*, black and red coat colours in cattle, one of the members of the alternative pairs of characters is completely dominant to the other. The black animal that carries red germ cells is quite as black in appearance as the true breeding black that carries black germ cells only. This feature of complete dominance is found frequently in animals, but there are other cases in which it is possible to distinguish by appearance, the form that carries both kinds of germ cells. Roan Shorthorns provide an illustration.

No breeder has succeeded in establishing a strain breeding true to roan, for such animals, when bred together, always throw reds and whites in addition to roans. Statistical examination of the herd books by several writers suggests that two kinds of germ cells are concerned, *viz.*, " red " and " white." When two " red " germ cells meet, a red † animal results, and such animals breed true to red; also, when two " white " germ cells meet, the result is a white, and such animals breed true to white. When, however, a red is crossed with a white, as shown in Fig. 1, a union is effected between a " red "

* Reprinted from *Jour. Min. Agri.*, XXVIII, no. 2.

† Both reds and roans may have white markings, especially on the belly, but these appear to be independent of the roan character.

and a " white " germ cell. The resultant animal is a roan, more or less intermediate in appearance between full red and white. This animal, formed by two unlike germ cells, carries both " red " and " white " germ cells in equal numbers; consequently, when roans are mated together equal numbers of " red " and " white " ova are fertilized by equal numbers of " red " and " white " sperms. Each " red " ovum has an equal chance of being fertilized by a " red " or by a " white " sperm; in the former case it will give a pure red animal, and in the latter a roan. Also, each " white " ovum has an equal chance of being fertilized by a " red " or " white " sperm; in the former case a roan animal will result

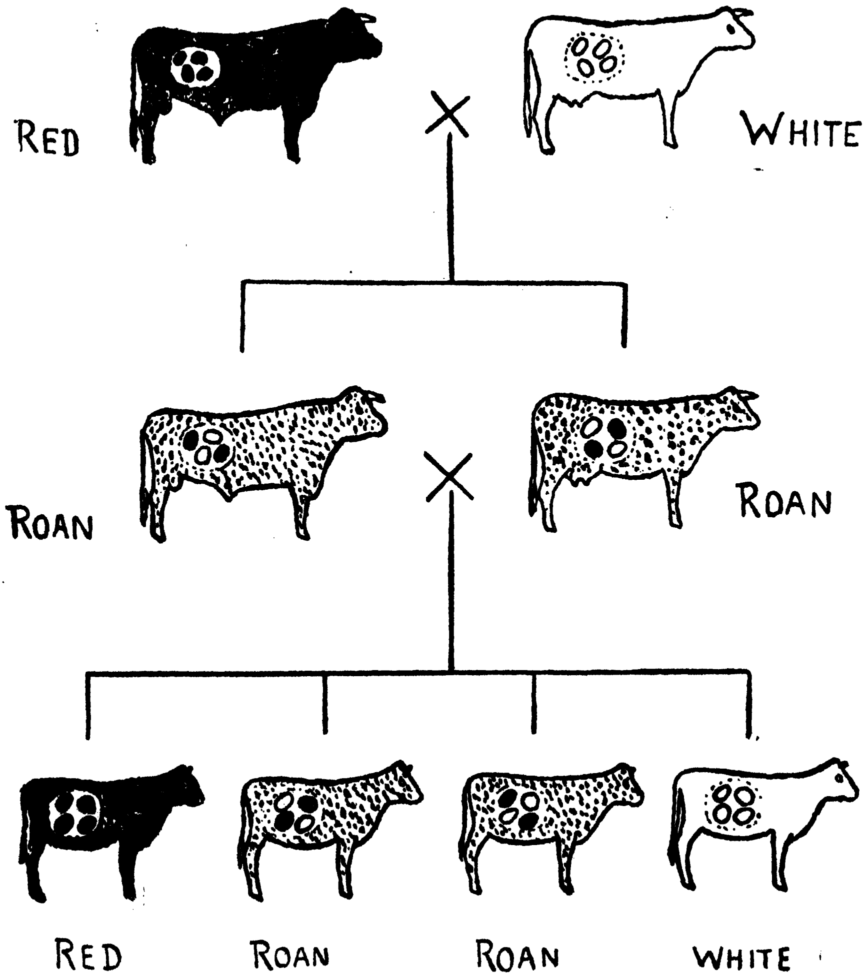

Fig. 1. Illustrating the relations of Red, White and Roan.

and in the latter a white. Roans mated together, as shown in Fig. 1, give reds, roans and whites in the ratio 1 : 2 : 1. From the view of the practical breeder a roan animal is a hybrid between red and white; the colour cannot be fixed, for there are no "roan" germ cells (only "red" and "white" cells). The breeder who desires roan animals will be well advised to obtain them by crossing red with white; in this way 100 per cent. of roans will result, as against 50 per cent. from mating roan by roan, roan by red, or roan by white.

The "breaking up of the type" that often occurs after a cross is a familiar feature to breeders. The first cross animals may show considerable uniformity, though differing from both parental strains. In one character they may take after one parent, in another they may resemble the other parent, while in a third they may be more or less intermediate between the two. When such animals are bred together a great diversity of forms makes its appearance in the next generation, and in extreme cases scarcely any two beasts may be

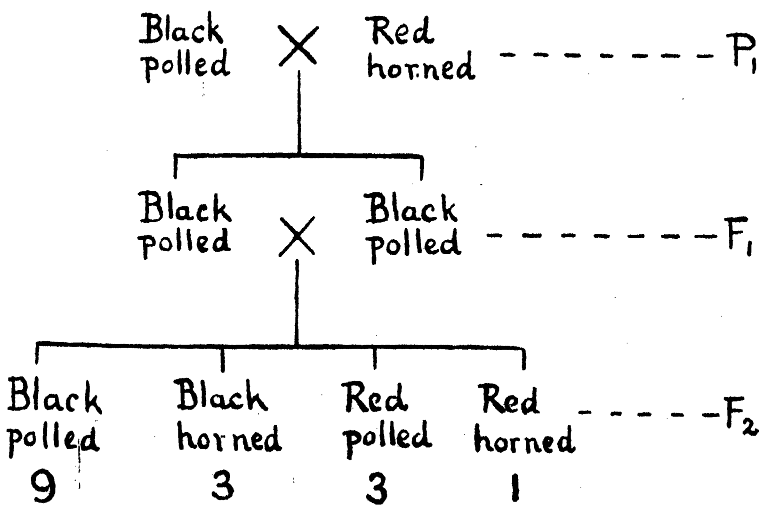

Fig. 2. Illustrating the relations of polled and horned cattle.

alike. The skilled breeder, however, will often name with certainty the original parental breeds of such a mixed progeny, as he will understand that there is something orderly underlying apparent chaos. Th ebreeder who sees as far as this will doubtless welcome

the simple explanation that Mendelism affords, but for those who may doubt the possibility of such an explanation, a simple example is given to illustrate the nature of the principle involved.

Suppose a cross is made between a black polled and a red horned breed. The progeny will be black polled animals. (Fig. 2.) The F_1 generation is uniform, but when a further generation is raised from these, fresh types appear. In addition to black polled and red horned beasts there will be horned blacks and polled reds, types distinct both from parents and grandparents, but evidently a recombination of characters found in the grandparents. These four types appear in widely different proportions, as indicated by the numbers in Fig. 2. It has been pointed out already that polled and horned cattle form a pair of alternative characters, of which polled is dominant; and that black and red form a similar pair, the black being dominant. Knowing this, we should expect all the F_1 beasts to be both black and polled; the F_2 generation to consist of blacks and reds in the ratio 3 : 1, and polled and horned in the same ratio. If we suppose that the factors for the black-red and the polled-horned pairs are transmitted in the same manner, *but independently of one another*, we must obtain a F_2 generation consisting of the four classes black-polled, black-horned, red-polled and red-horned in the ratio 9 : 3 : 3 : 1. This is the only ratio in which the polled and horned appear in the proportion 3 : 1, and the blacks and reds simultaneously in the same proportion, provided that each pair is inherited independently. Though the ratio 9 : 3 : 3 : 1 has not been verified on a comprehensive scale for the cattle cross, it has been worked out in all details in many cases for smaller animals, where the expenses of breeding are far less. There is reason for supposing that if a F_2 generation of several hundreds of cattle were bred from this cross, the four classes mentioned would be obtained in the proportions given above.

There has been a "break-up" of the parental types in that the two new classes, horned-blacks and polled-reds, appear in the F_2 generation; and it is clear that these new classes arise through recombination of the two pairs of factors in which the original parents differed. The "break-up," however, is not marked, because

the parents differed in two pairs of factors only. Had they differed in ten pairs the F_2 generation would have been very much more complex, and the feature of recombination, so obvious in the simpler case, would have been obscured by the great number of recombinations that would have appeared. Nevertheless, on the evidence obtained from smaller animals, there is good reason for supposing that the more complicated case could be resolved on the same lines as the simpler one, and that the same principle underlies both.

A cross may be undertaken deliberately with the idea of combining particular characters found in one breed with other characters found in another breed, and with this in view it is clear that Mendelian principles can be of great assistance to the breeder. Let us suppose that the breeder wishes to obtain a strain of red polled cattle out of Aberdeen Angus and Red Shorthorn; and further, that he is not aware of the fact that polled and horned, and black and red behave as simple Mendelian pairs. From this crossing only polled blacks result. So far he can say only that the Angus is prepotent; but as soon as he raises a F_2 generation and views it in the light of Mendelian knowledge, he begins to understand what is happening. The fact that he gets no intermediates, but only blacks and reds in the F_2 generation, and that the latter form about one-quarter of the total tells him that these colours depend upon a single pair of factors. From the point of view of horns in the F_2 generation, it will be noted that polled and horned appear in the ratio 3 : 1; and this tells the breeder that he is dealing with another pair of factors. Moreover, the 9 : 3 : 3 : 1 ratio tells him that the two pairs are transmitted independently; for this is the meaning of the 9 : 3 : 3 : 1 ratio in analysing the phenomena of heredity.

Having obtained the polled reds the breeder wants to fix them in the shortest time. To a problem of this sort Mendelian theory may be a valuable guide. When once the factors concerned in a cross have been determined, it is possible to calculate the proportion of fixed animals in each class of the F_2 generation, and to suggest also how they are to be found. In explanation we may examine the cattle cross from a slightly different point of view. The nature of the F_2 generation tells us that we are concerned with a difference

of two pairs of factors, *viz.*, the pair for polled and horned denoted by *P* and *p*, and the pair for black and red *B* and *b*.* It is clear that both dominants went in with the Angus and both recessives with the Shorthorn: therefore, we denote the polled black as *PPBB* and the Shorthorn as *ppbb*. Since the F_1 gets *P* and *B* from its Angus parent, and *p* and *b* from its Shorthorn parent, its constitution must be *PpBb* (Fig. 3). When F_1 forms germ cells, each cell contains a representative of the *P-p* pair, and also a representative of the *B-b* pair. Hence 50 per cent. contain *P* and 50 per cent. contain *p*; also 50 per cent. contain *B* and 50 per cent. contain *b*. Since the F_2 generation shows that the *P-p* pair and the *B-b* pair are transmitted independently, we must suppose that any germ cell containing *P* has an equal chance of containing either *B* or *b*, and similarly, any *p* germ cell has an equal chance of containing *B* or *b*.

Hence the F_1 animals will produce the 4 kinds of germ cells *PB*, *Pb*, *pB* and *pb*, and produce themein equal numbers. When F_1 beasts are mated together it means that we are bringing together a series of ova of this nature with a similar series of sperms. The simplest way to arrive at the result is to make a figure of 16 squares, as shown in Fig. 3, and to write the above series of germ cells first across the four horizontal rows of the figure, and then down the four vertical rows of the same figure. This will give all the different possible combinations in the proportions in which they may be expected to occur, *i.e.*, the constitution of the F_2 generation. Examination of the squares shows that 9 out of the 16 contain both *P* and *B* and are, therefore, polled blacks, 3 contain *B* and *p*, which are horned blacks; 3, in which *P* is associated with *b*, are polled reds; while 1, having only *b* and *p*, must be red horned. The three red polled are not all alike. One is *PPbb* and two are *Ppbb* (Fig. 3, squares numbered 6, 8, and 14). The former is pure for the polled factor, having received it from both parents; the others, however,

* It is customary to denote the factor that gives rise to the dominant of a pair of alternative characters, by a capital letter, and that upon which the recessive depends, by the corresponding small letter.

Black polled	Red horned
PPBB	ppbb
forms germcells	forms germcells
PB PB	pb pb

PpBb	PpBb
Black polled	Black polled F_1
forms germcells	forms germcells
PB	PB
Pb	Pb
pB	pB
pb	pb

giving rise to an F_2 generation :—

PB PB 1. Black polled	PB Pb 2. Black polled	PB pB 3. Black polled	PB pb 4. Black polled
Pb PB 5. Black polled	Pb Pb 6. Red polled	Pb pB 7. Black polled	Pb pb 8. Red polled
pB PB 9. Black polled	pB Pb 10. Black polled	pB pB 11. Black horned	pB pb 12. Black horned
pb PB 13. Black polled	pb Pb 14. Red polled	pb pB 15. Black horned	pb pb 16. Red horned

Fig. 3. Illustrating the relations of Aberdeen Angus and Red Shorthorn.

have received it from one parent only, and are consequently impure. The polled character is already fixed in one-third of the red polled F_2 beasts, but how are they fixed to be distinguished from the unfixed beasts? As pointed out in the previous article, this can be done by crossing with the recessive, which in this case is the horned beast. The fixed polled red *PPbb* gives only polled beasts when mated with horned animals, the impure polled red *Ppbb* gives on the average equal numbers of polled and horned. The above example was selected as a very simple illustration of the manner in which the "break-up" of the type, and the recombination of characters is interpreted on Mendelian lines, but the general principle applies to far more complicated cases. It has provided us with a simple explanation of the curious phenomenon of reversion on crossing, a phenomenon which has puzzled the practical breeder and the man of science. As, however, no fresh principle is involved in such cases, there is no need to consider them here in further detail.

Many of the characters of animals with which the breeder deals owe their manifestation to the presence of one or other definite factor, which is transmitted according to a definite scheme. If these factors are not divisible under normal conditions, they must be handed on through the germ cells as definite entities producing their full effect in each successive generation. Continual crossing of black with red does not diminish the potency of the black factor. So long as it is passed on through a germ cell it produces its full effect. This relative permanence of the factors, assuming it to be well founded, is doubly important for the animal breeder. It assures him that a character put into a cross can be recovered from it by suitable procedure, even though it may for a time appear to be submerged and lost. It also offers the prospect of understanding and so of controlling fully the material with which he works; but in order that he may be in a position to do this he must first be provided with an analysis of that material in terms of factors. The factor is for the breeder much what the atom is for the chemist. Though they may have a real existence, in practice both the atom and the factor are used as symbols. The chemist analyses his material in terms of atoms that he has never seen, but the conception of their

existence is justified by the control he obtains when using the atomic theory as his guide. The theory guides the analysis that enables him to build up a conception of the chemical constitution of the substance he examines, and this conception enables him to predict the behaviour of the substance in its various reactions. Understanding the atomic nature of the substance, he can thenceforth control it; so also, the biologist is attempting to analyse his material in terms of factors which he has never seen. For if factors are something definite and permanent, following a definite scheme of distribution in heredity, it is clear that the characters of living things can be brought under accurate control by the breeder. They can be dissociated and recombined, just as the chemist dissociates and recombines atoms to make new substances.

This work of analysing the living beast is only beginning. It is only within recent years that the factorial theory of heredity was enunciated, and the scientific man is still busy testing how far it is sound. In simple cases, such as those described above, it has certainly borne the test. The skipping of characters for a generation—the persistence of the unwanted recessive even in most highly pedigreed flocks and herds—the unfixable nature of certain types—the explanation of the curious phenomenon of reversion on crossing—the meaning of the break-up of the type in the second generation from a cross—the principles governing the recombination of characters—all these things are now straightforward, and will be found treated of in a text-book dealing with heredity. But can we interpret in terms of the factorial theory those cases, where at first sight there appears no suggestion of clear cut alternative pairs of characters—where a cross seems to result in a muddled blend—or must we confess that no solution has been found? It is such problems as these that have been engaging our attention at Cambridge for some years past, and a brief account of them will be given in the two following articles.

MOSAIC DISEASES OF PLANTS.*

BY

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THAT plants, like animals, are subject to definite diseases, has been recognized from the earliest times, and in the case of affections so important to man as, for instance, "rust" of wheat, it was natural that there should be much speculation as to the nature and cause of disease. The earliest writers adopted either entirely superstitious views, or attributed plant diseases to definite environmental factors, as drying winds, unfavourable soil, and so on. Even when later the constant association of certain fungi with disease was noted, these were not recognized as entities, but were regarded as special manifestations of the diseased condition—products of the changed sap of the plant.

With the researches of De Bary and others in the latter part of the nineteenth century on the parasitism of fungi, there began a new era in the study of plant pathology. The fungi connected with many diseases were identified, their life-histories studied, and the causal relationships established by means of pure culture methods and infection experiments. Later, many other diseases were shown to be similarly caused by bacteria. There still, however, remained a number of affections which could not be attributed to any known organism. These have been classed under the term "physiological diseases." A critical examination of our knowledge as to these

* *West Ind. Bull.*, XVIII, no. 4.

diseases reveals the fact, as R. E. Smith[1] has pointed out, that they are a heterogenous collection of phenomena, agreeing in nothing except that their cause is not known. The further conception that the diseased condition is the manifestation of some functional or metabolic disturbance is purely an assumption. Certain diseases, at one time thought to be "physiological," have since been proved to be connected with parasitic organisms.

Within the past thirty years much literature has accumulated on the subject of one group of these so-called physiological diseases, which have certain features in common. While no recognizable organism has been found, the symptoms are entirely those of attack by a parasite, and there is a strong body of opinion inclining to the belief that there may be involved an ultra-microscopic parasite—a conception which has already been adopted in animal pathology.

These are all mosaic diseases, so called because the most usual and conspicuous symptom is a mottling effect on the leaves of diseased plants caused by the presence of irregular lighter green areas mingled with the general green groundwork of the leaf.

Mosaic diseases provide an exact parallel with certain animal diseases, such as small-pox and infantile paralysis, which are regarded as being caused by ultra-microscopic organisms. They are more or less readily communicable, and the sap of diseased plants can be filtered through ordinary bacteria-proof filters without losing its infectious properties. Furthermore, the disease is frequently transmitted to healthy plants through the agency of insects, such as aphides, which infest them (*cf.* Rand and Pierce).[2]

The best known and most thoroughly investigated of the mosaics is that of tobacco. Tobacco mosaic manifests itself in various ways. The plant may show partial or complete chlorosis, or may be entirely dwarfed. In other cases, the leaves show curling, dwarfing, blistering, and distortion, or a mottling with different shades of green. The flowers may also be distorted, and in *Nicotiana*

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[1] Smith, Ralph E. The investigation of Physiological Plant Diseases. *Phytopathology*, V, 1915, pp. 83–93.

[2] Rand. F. V., and Pierce, W. D. A Co-ordination of our knowledge of Insect Transmission in Plant and Animal Diseases. *Phytopathology*, X, 1920, pp. 189–231.

tabacum the normally pink flowers become entirely bleached or blotched with white.

The closest search has failed to reveal any recognizable organism to which the disease could be attributed, yet it has been shown to be highly contagious. The disease may be communicated to a healthy plant by rubbing the leaves with juice from a diseased plant, or by merely rubbing with the finger, after dipping them in infected juice. The infectious principle is not removed by filtration through ordinary bacteria-proof filters, but Allard succeeded in removing it by means of a Livingston atmometer porous cup. At the same time the filtrate showed an intense peroxidase reaction, thus indicating that the infective principle is not an enzyme of this nature.

The properties of the virus of tobacco mosaic have been investigated in some detail by Allard [1, 2, 3, 4, 5]. It remains equally infective at a dilution of 1 part of virus in 1,000 parts of water, though at greater dilutions the infective power is impaired. In such dilute solutions, the peroxidases give no discernible reaction. The enzymes present in a healthy plant, on the other hand, can be brought to a high degree of concentration, and yet never acquire infectious properties.

The virus is markedly resistant to solutions of various salts, antiseptics, etc., unless these are very concentrated. Of all the substances tried, only formaldehyde and alcohol stronger than 50 per cent. were found to destroy the infective principle easily. It is quickly killed at temperatures near the boiling point of water,

[1] Allard, H. A. The Effect of Dilution upon the Infectivity of the Virus of Mosaic Disease of Tobacco. *Jour. Agri. Res.*, III, 1915, p. 295.

[2] Allard, H. A. Distribution of the Virus of the Mosaic Disease in the Capsules, Filaments, Anthers, and Pistils of affected Tobacco Plants. *Jour. Agri. Res.*, V, 1915, p. 251.

[3] Allard, H. A. Some properties of the Virus of the Mosaic Disease of Tobacco. *Jour. Agri. Res.*, VI, 1916, p. 649.

[4] Allard, H. A. Further Studies of the Mosaic Disease of Tobacco. *Jour. Agri. Res.*, X, 1917, p. 615.

[5] Allard, H. A. Effects of various Salts, Acids, Germicides, etc., upon the Infectivity of the Virus causing the Mosaic Disease of Tobacco. *Jour. Agri. Res.*, XIII, 1918, pp. 619–637.

but is more resistant when dried, and is very resistant to low temperatures, surviving exposure for fifteen minutes even to 180°C.

As already mentioned, tobacco mosaic is easily transmitted in the course of handling the plants, and it has also been shown that, in nature, certain aphides are instrumental in spreading the disease from plant to plant. Infection is, however, not carried through the seed. While the virus has been shown to be present in every other part of the plant, even in the trichomes, it is absent from the embryo, and if seed is produced by a mosaic tobacco plant, the seedlings remain healthy unless infected from outside. The same holds for certain other mosaic diseases as spinach blight, and possibly tomato mosaic, though in this latter case the evidence is conflicting. In cucumber and bean mosaic, however, seed transmission takes place.

The virus from tobacco will also produce a similar disease in certain other solanaceous plants, as tomato and petunia. It has been shown by Nishimura[1] that *Physalus alkekengi* may act as a carrier of the mosaic of Solanaceæ, without itself showing any symptoms of disease. This possibility of 'carriers' has to be borne in mind when dealing with supposedly immune varieties of plants susceptible to mosaic. The mottling disease of sugarcane was probably introduced into Argentina by resistant varieties showing little sign of infection (Earle).[2]

Within recent years, it has been shown that the disease of potatoes known as "leaf-curl," "curly-dwarf," or mosaic is also of an infectious nature, and is caused by a virus in which no visible organism can be detected. Although infection of potato can be obtained from tomato by grafting, it has not been possible to tansmit the disease from tobacco. Artificial transmission of leaf-curl is not so easy as in the case of tobacco mosaic, but may be effected by certain methods as by rubbing together leaves of diseased and

[1] Nishimura, M. A Carrier of the Mosaic Disease. *Bull. Torr. Bot. Club*, **45**, 1918, pp. 219-223.

[2] Earle, F. S. The Resistance of Cane Varieties to the Yellow Stripe or Mosaic Disease. *Porto Rico Dept. Agri. Ins. Expt. Sta. Bull.* 19, 1919.

healthy plants. It has been found also that infection may take place in nature by root contact (Quanjer).[1]

A second potato disease, known as leaf-roll, is also contagious, but is apparently distinct from potato mosaic. Leaf-roll is characterized by necrosis of the phloem, causing stoppage in the translocation of starch from the leaves. Both diseases are transmitted by the tubers and from plant to plant through the roots. Mosaic or leaf-curl has been found also to be transmitted by certain aphides.

Outside the Solanaceæ, mosaic diseases are known in many other cases; amongst others, *Phytolacca decandra*, sugar-beet (curly-top), spinach (blight), cucumber, sweet pea bean and other Papilionaceæ, beet and sugarcane. All of these are characterized by the presence of more or less mottling or distortion of the leaves, and in most cases transmission by insects has been proved.

Insect transmission of the disease has been perhaps most thoroughly investigated in the case of curly-top of sugar-beet. This disease was shown by E. D. Ball[2] and Shaw[3] to be communicated by the beet leaf-hopper (*Eutettix tenella* Baker). The question has been tested experimentally by numerous investigators, and it has been shown conclusively that the leaf-hoppers are not in themselves infective, but only become so after feeding on diseased plants. No more than three hours' feeding is necessary for the leaf-hopper to obtain the infective principle, but an incubation period of forty-eight hours, or possibly only twenty-four, is necessary before the insect can induce the disease (Smith and Boncquet).[4] This latter fact suggests that some development takes place within the body of the insect. To induce the disease in a healthy beet, it is sufficient to confine one virulent leaf-hopper for five minutes on a leaf of the plant. Of great importance in connexion with the

[1] Quanjer, H. M. The Mosaic Disease of the Solanaceæ, its relation to Phloem-necrosis and its effect upon Potato-culture. *Phytopathology*, X, 1920, pp. 35–46.

[2] Ball, E. D. The Beet Leaf-Hopper (*Eutettix tenella*). *Utah Agri. Expt. Sta. 16th Ann. Report*, 1904-05, 1906.

[3] Shaw, H. B. The Curly-top of Beets. *U. S. Dept. Agri. Bur. Plant Indus. Bull.* 181, 1910.

[4] Smith, R. E., and Boncquet, P. A. New Light on Curly-top of the Sugar-beet. *Phytopathology*, V, 1915, pp. 103–107.

perpetuation of the disease, from season to season, is the fact shown by Boncquet and Stahl,[1] and by Carsner,[2] that various wild plants are susceptible to the virus, and, further, that leaf-hoppers may retain their virulence for a long time, even when feeding on non-infected plants. Carsner considers it highly probable that overwintering of the virus is accomplished by these two factors.

Cucumber mosaic has also been communicated to various plants of the same family, including the wild cucumber (*Micrampelos lobato*). In the latter plant occasional transmission of the disease through the seed has been observed,[3] but seed transmission appears to be the exception rather than the rule in mosaic disease in general. Bean mosaic, however, appears to be carried by the seed, and is not readily communicated from plant to plant. In this case high temperatures and great humidity are found to favour infection.

The case of spinach blight is interesting. This disease is carried by aphides, and McClintock and Smith[4] have shown that the infectious principle may be transmitted from the parent aphides to their offspring, through a period sufficiently long to tide over the interval between successive spinach crops. A similar inheritance of the virus is known in the case of some animal diseases.

At the present time this interest is centred in sugarcane mosaic owing to its rapid spread in the West Indies and the losses caused by it. The disease has been known in Java since 1892, although its infectious character was not then recognized. It was first noted in Porto Rico about the middle of 1916, when only a small area was affected. By 1919, more than three-fourths of the cane-fields of the islands were involved, and the disease had appeared also in Santo Domingo (Cuba) and St. Croix. In the present year it has been

[1] Boncquet, P. A., and Stah', C. F. Wild Vegetation as a Source of Curly-top Infection of Sugar-beets. *Jour. Econ. Ent.*, X, 1917, pp. 392–397.

[2] Carsner, E. Susceptibility of various plants to Curly-top of Sugar-beet. *Phytopathology*, IX, 1919, pp. 413–421.

[3] Doolittle, S. P., and Gilbert, W. W. Seed Transmission of Cucurbit Mosaic by the Wild Cucumber. *Phytopathology*, IX, 1919, pp. 326-327.

[4] McClintock, I. A., and Smith, L. B. The true nature of Spinach Blight and the relation of Insects to its Transmission. *Jour. Agri. Res.*, XIV, 1918, pp. 1–60.

causing trouble in Jamaica[1] and Trinidad,[2] and has recently appeared in Barbados.

The disease manifests itself first in a mottling of the whole of the leaf with pale-green to whitish streaks and spots. The pattern varies in different varieties of cane, and may be constant and characteristic in some kinds. Spots caused by other agencies are sometimes liable to be confused with mosaic, but the latter is generally recognizable by the pale-green, not yellow, colour of the blotches, their linear shape, and occurrence over the whole surface of even the youngest leaves.

In plant canes originating from diseased cuttings, all the leaves are affected, and in the second and third years there may be a further development on both leaves and stem of white opaque patches. The occurrence of internal lesions in diseased stems has also been recently recorded. (Matz)[3]: the effects of the disease are cumulative. Diseased canes weigh less than healthy canes, and a considerable reduction in yield is the result. Except when the stem becomes cracked, however, the sugar content of the juice is not materially affected.

In addition to primary infection through the use of diseased seed-pieces, the rapid spread of the disease early gave indication that secondary infection takes place in nature. The growing point is infected, and all leaves formed subsequently show the mottled effect. If the infection occurs late, only the upper part of the cane shows disease, and the lower joints may give rise to sound plants or ratoons. Healthy shoots from diseased stools, when used as seed, similarly give rise to healthy plants. In this respect the virus of sugarcane mosaic differs from that of tobacco which penetrates to all parts of the plant wherever it may be introduced.

[1] Ashby, S. F. The Mosaic, Mottling, or Yellow Stripe Disease of Cane. *Dept. Agri. Jamaica, Leaflet*, 1920.

[2] Williams, C. B. Mosaic Disease of Sugarcane in Trinidad. *Agri. News*, XIX, 1920, . 126, and *Bull. Dept. Agri. Trinidad and Tobago*, XIX, 1920, pp. 30–36.

[3] Matz, J. Infection and Nature of the Yellow Stripe Disease of Cane (Mosaic, Mottling, etc.). *Jour. Dept. Agri. Porto Rico*, III, no. 4, October 1919 (published 1920).

It has not been easy to prove experimentally the infectious nature of the virus of sugarcane mosaic, but Brandes[1] has shown that the disease may be transmitted by the corn aphis. It is unlikely that this insect is the only agent acting under natural conditions, but so far experiments with other insects have given no conclusive results. While all the observed facts point to insect transmission, the case remains not proved.

Unlike tobacco mosaic, the sugarcane disease can only be transmitted artificially with difficulty, under conditions at present not understood. Brandes[2] was successful only when he injected ½ c.c. of the virus into the growing-point by means of a hypodermic syringe. It is perhaps worthy of note that he obtained better results with virus which had been pressed out from the shoot under oil, and thus remained unoxidized, than with virus obtained by trituration of young leaves. A repetition of this method by Earle[3] in Porto Rico gave in one case five infections out of ten, but in two duplicate experiments no positive results were obtained. Tests of other methods of infection similarly show no uniformity, and there is evidently some factor in operation which is not at present understood.

Quanjer,[4] in connexion with phloem-necrosis of potato, has suggested the possible action of anaerobic organisms. The behaviour of the virus of sugarcane mosaic seems to lend some support to this idea, but further experiments are necessary before any conclusions can be drawn.

In a recent publication, Matz[5] describes a plugging of the parenchyma cells in diseased leaves and stalks by a dense, plasma-like substance, with a tendency to break up later into small motile

[1], [2] Brandes, E. W. Artificial and Insect Transmission of Sugarcane Mosaic. *Jour. Agri. Res.*, XIX, 1920, p. 131.

[3] Earle, F. S. The Year's Experience with Sugarcane Mosaic or Yellow Stripe Disease. *Jour. Dept. Agri. Porto Rico*, III, no. 4, October 1919 (published 1920).

[4] Quanjer, H. M. On the Nature, Mode of Dissemination and Control of Phloem necrosis (Leaf Roll) and Related Diseases. *Meded V. d. Rijks Hoog. Land, Tuin, en Bosch-bouwschool*, X, 1916.

[5] Matz, J. Infection and Nature of the Yellow Stripe Disease of Cane (Mosaic Mottling, etc.). *Jour. Dept. Agri. Porto Rico*, III, no. 4, October 1919 (published 1920).

granules. The observation seems to provide at least a histological basis for the disease.

More than 1,900 varieties of cane are known to be subject to mosaic, and the list includes practically all of those which are commercially esteemed. The Otaheite or Bourbon cane is very severely injured, while Rayada, Crystalina and Yellow Caledonia also suffer badly. Louisiana, Barbados, Demerara, as well as Trinidad and other seedlings are attacked, though in varying degrees. In fact few varieties appear to be immune, but slender canes of North India type, generally known as Japanese canes, are said by Brandes[1] to be resistant under Louisiana conditions. The variety Kavangire, or Uba, has never been observed to show signs of disease.

One of the most disquieting features of the disease, complicating the question of control, is the fact that other cultivated and wild grasses have been found to be susceptible. The mosaic disease of sugarcane has been proved to be transmissible to maize, sorghum, crab grass (*Syntherisma sanguinalis*), foxtail (*Chætochoa lutescens*), and *Panicum dichotomiflorum*. A similar disease has also been observed on rice and millet (*Panicum crusgatti* Major) in Porto Rico (Brandes)[2], [3].

The only satisfactory method of controlling the disease is by seed-piece selection and eradication. It is transmitted by the use of diseased seed pieces, and neither disinfection of the seed nor soil treatment has any beneficial effect. Infection is not carried by the soil.

Earle[4] has recorded the promising results of eradication experiments in Porto Rico. In the first place, only healthy cuttings should be planted. Then, when the young cane is about a foot high, the field is inspected, and all plants showing signs of disease are pulled out. This inspection and roguing is repeated at intervals of ten days, until no more cases are found.

[1], [2] Brandes, E. W. The Mosaic Disease of Sugarcane and other Grasses. *U. S. Dept. Agri. Bull.* 829, 1919.

[3] Brandes, E. W. Mosaic Disease of Corn. *Jour. Agri. Res.*, XIX, 1920, pp. 517–521.

[4] Earle, F. S. Eradication as a means of control in Sugarcane Mosaic or Yellow Stripe. *Porto Rico Dept. Agri. Bull.* 22, 1919.

Brandes[1] recommends roguing only when the amount of infection in the young canes does not exceed 20 per cent. or in half grown to mature canes 5 per cent. The size of the field and the condition of the surrounding fields must also be taken into consideration. It is suggested that as soon as all the plants have sprouted, the fields should be inspected, and all diseased stools pulled out and cast between the rows. A second inspection after a lapse of twenty-five to thirty days will show whether secondary infection is taking place. If so, the fields should be rogued as before, and a third inspection made again after the same interval, twenty-five to thirty days. It may be necessary to repeat the process several times.

In large, badly infested fields, roguing is impracticable. In such cases, Brandes suggests that the crop should be allowed to mature, every stalk ground, and the stubble ploughed up and killed. Replanting should be done with carefully selected cuttings. As a precautionary measure, some crop other than a grass might be grown on the land for a year.

Naturally the success of this method depends on its being carried out thoroughly throughout the infected region. As already indicated, the discovery of other hosts has complicated the problem. The disease is perpetuated in perennial grasses, and the destruction of all affected host-plants is practically impossible. When once the planter realizes the seriousness of the situation, however, much can be done to minimize losses by thorough roguing methods. Unfortunately. the substitution of immune varieties does not at present offer any immediate solution, for in the case of both cane and corn, the susceptible varieties happen to be the most esteemed.

It may be mentioned in passing that Brandes[2] has observed several cases of apparent recovery from mosaic in the case of maize, crab-grass, and foxtail. He also states that occasionally suckers from diseased stools of sugarcane and sorghum have been observed to come up with no sign of mosaic. Inoculation experiments only will decide whether in such cases the virus is really absent or only

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[1] Brandes, E. W. The Mosaic Disease of Sugarcane and other Grasses. *U. S. Dept. Agri. Bull.* 829, 1919.

[2] Brandes, E. W. Mosaic Disease of Corn. *Jour. Agri. Res.*, XIX, 1920, pp. 517–521.

inactive. Brierley,[1] however, has recorded a case of what appears to be true recovery from mosaic disease of tomato. Freiberg[2] has attempted to explain it on the basis of temperature relations, but this explanation does not quite cover the facts. All these occasional records of recovery are at present unexplained.

There are a certain number of other obscure diseases of plants, which while not agreeing with the true mosaics in their symptoms yet appear to be transmissible, and caused by an infectious virus. Among these may be mentioned such diseases as peach "yellows," "sereh" disease of sugarcane, "spike" disease of sandal, etc. In most of these cases the information yet available is scanty.

With regard to the nature of the "virus" causing these various diseases, the theory first advocated, and still held by many workers, is that the infective principle is an enzyme. Allard's experiments proved conclusively that at least it was not an oxidase, for he was able to show that the infective principle and the oxidizing enzymes react independently.

Freiberg[3] has since confirmed this result, but he adheres to the enzymic theory, supposing that the substance in question is of the nature of an aldehydase. Having found that carbohydrates are more abundant in the dark-green than in the light-green areas of the leaf, he connects this with the fact that formaldehyde is probably one of the first products of photosynthesis. Thus he explains the fact that Allard found the infective principle was destroyed by formaldehyde, as due to a specific chemical reaction with the formaldehyde, and not to its antiseptic properties.

The behaviour of the virus of mosaic disease of tobacco with respect to high and low temperatures and various antiseptic solutions is certainly more in accord with that of an enzyme than with that of any organism at present known.

On the other hand, the great objection to the enzyme theory appears to be the difficulty of explaining how such a catalyst would

[1] Brierley, W. B. On a case of Recovery from Mosaic Disease of Tomato. *Ann. App. Biol.*, II, 1916, pp. 263–266.

[2],[3] Freiberg, G. W. Studies in the Mosaic Diseases of Plants. *Ann. Miss. Bot. Gard.*, IV, 1917, pp. 175–232.

originate. If one adopts this view, it is necessary to assume that at some period an enzyme, or a substance capable of activating enzymes, has arisen in the plant *de novo* possibly, as Freiberg suggests, in consequence of some disturbance in metabolism. Were this the case it should be possible to induce the disease at any time, by engendering such a disturbance in the activities of the plant cell. As far as experiments have gone at present, however, we know of no means of producing mosaic disease in a healthy plant, except by infection from another diseased plant.

On the other hand, none of the properties of the virus so far investigated is entirely inconsistent with the theory of the presence of an organism. In particular, the fact that the virus remains active, even in extreme dilution, and is capable of increasing indefinitely within the tissues of the host, points to the action of a living organism rather than of a chemical substance. Freiberg's observations as to the existence of a maximum, optimum, and minimum temperature for the manifestation of mosaic disease are equally in accordance with the view that a parasite is present.

Until comparatively recently, the conception of such ultramicroscopic organisms remained entirely theoretical. The work of Löhnis and Smith[1] in 1916, however, on the life-cycles of bacteria, opened up entirely new possibilities in connexion with this as well as certain other pathological problems. Löhnis and Smith found that bacteria may enter an amorphous "symplastic" stage, in which condition parasitic species might not be readily distinguishable from the protoplasm of the host cell in which they occur. Furthermore, they observed the formation of filterable "gonidia," which may produce new bacteria directly, or after having entered the symplastic stage. In view of these facts, the possibility that eventually many of the infectious filterable viruses will be proved to contain living organisms is brought appreciably nearer.

[1] Löhnis, F., and Smith, N. R. Life and Cycles of the Bacteria. *Jour. Agri. Res.*, VI, 1916, pp. 675–702.

A SERIES OF MANURIAL EXPERIMENTS AT LYALLPUR, 1912–1917.*

BY

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THE experiments now reviewed were started with the object of discovering the "dominant" manurial ingredient for each of the common crops of the canal colonies. Any consideration of the economic aspects of the question was deliberately postponed for subsequent investigation. The way in which the crops are rotated, even, is not typical of the practice of the district. The crops of the two seasons are grown in two separate series. In the *kharif* (monsoon) series, sugarcane, maize and cotton, and in the *rabi* (winter) series, wheat, *toria* (*Brassica campestris* var. *napus*) and gram, follow each other in the order given. The intensity of cropping is thus 100 per cent. (one crop per year) which is the average of the district as a whole. But, on the other hand, it is not common for rotations consisting of the crops of one season only to be adopted at all, and this is never done when the land is manured. The customs of the local zemindars as to the order in which crops are rotated are still somewhat variable; but on one point there is a general agreement. For whenever a field receives a dressing of farmyard manure, which is the only manure commonly used, then two crops are always grown in succeeding seasons without any intervening fallow period.

The utility of the results of these experiments for practical purposes is also greatly diminished by the absence of any unmanured

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control plots. Between each of the manured plots of one-fifth of an acre there is a very narrow strip of unmanured land. But these strips are very small and are relatively greatly affected by border effects—effects which in manurial experiments on irrigated land are by no means negligible. Thus although the yields of these strips have been systematically recorded, they are useless for any strict comparisons: they have only been used in the preparation of Table I and in the calculation of the figures for probable "error" in Table II.

Farmyard manure.

In each series in each year there is a plot manured with farmyard manure consisting chiefly of dung. In Table I the yields of these plots have been compared to the yields of the adjacent unmanured strips. Very similar figures are obtained by comparing the yields of these plots with the average of the yields of all the unmanured strips instead of only the two adjacent ones.

Sugarcane gives a substantially increased yield on the manured plot, the increase amounting to 20–40 per cent. in all normal years: it is only in the years 1911 and 1914, when the whole crop was inferior, that the relative increase due to manuring is less. (For actual yields see Table II.) In each of the four years when the crop of maize was average to good, the manure causes an apparent increase of 10–20 per cent. The effect on cotton is more variable, though the cause of the variations is not obvious, as the crops were throughout average to good. In the case of wheat the actual yields are very consistent from year to year, and the increases due to the manure are also regular though small, averaging only 14 per cent. The effect of the manure on the yields of *toria* varies considerably from year to year. But the actual yields of the whole crops of *toria* vary greatly from year to year; for this crop is greatly affected by several seasonal factors. Generally the return from the manure is greatest in the best years. There is very little evidence in these results of any increase in the yield of gram as a result of applying farmyard manure.

So far as they go, these results accord exactly with the common ideas and general practices of the farmers in the district. Sugarcane and maize are regarded as most exhaustive crops and are always grown on the best land and receive most of the available manure. Cotton is regarded as less exhaustive, and is only manured when it is not preceded (as it is in these experiments) by any fallow period. Of the *rabi* crops, *toria* is regarded as the most exhaustive and is sometimes manured. Gram is regarded as the least exhaustive of the common crops and is very seldom manured. Certainly no one manures gram when it is grown, as it is in these experiments, on land that has been fallow for several months.

ARTIFICIAL MANURES.

The results from the application of various artificial manures are given in Table II, parts A and B. In these tables the yields from the plots manured with artificials are compared with the yields from the plots treated with farmyard manure. The yields and mean yields of the narrow unmanured strips are also given ; but as explained before too much weight cannot be attached to comparisons between the manured plots and these strips.

Lime. The yields from the limed plots are poor except when it is applied to wheat and gram. It is not unlikely that the lime may cause an increase in the yield of the leguminous gram crop ; and the apparent increase which it causes in the yield of wheat is sufficiently great possibly to represent more than experimental errors. Apart from these two cases the lime apparently fails to give any important return.

Gypsum. Except in one case (that of maize in 1911), there is no evidence in these experiments of any return from the applications of gypsum. Excepting in that one case, the yield from the gypsum plot is less than that from the dunged plot in all cases where the latter was itself at all superior to the unmanured strips. In the case of the gram crops and the cotton crop of 1914, where the farmyard manure itself produced little increase, there the yields of the gypsum plot and the farmyard manure plots are substantially equal. Comparing the yields of the gypsum plot and the unmanured strips

confirms the failure of gypsum. The one exceptional case is not easily understood ; but it is significant that it occurred in the first year of the experiments when there were also one or two other exceptional results, so that it may have been due to an irregularity in the soil which later disappeared under the continued good cultivation.

Bonemeal. The yields from the plot (No. 4) manured annually with 300 lb. of bonemeal is less than the yield from the dunged plot in every case except that of cotton in 1915, in which year the latter was itself inferior to the unmanured strips. The comparison with the unmanured strips, so far as it goes, shows no evidence of any very substantial returns from the manure. The yields of plot 24, treated with bonemeal and lime, look more encouraging at first sight ; but the only really marked increases, apparently due to the manure, are in the sugarcane crop of 1914, which was practically a failure, and in the gram crops where lime alone seems also to be beneficial. Plot 30 manured with bonemeal, lime and ammonium sulphate can also be compared with plot 26 which is treated with only lime and ammonium sulphate. On the whole the yields of the two plots are approximately equal. The former is distinctly superior in one year, but this is counterbalanced by a case in which it is equally inferior.

Basic slag. In the first year of the experiment basic slag apparently gave a good return when applied to sugarcane, but this result is not confirmed by the yields in the later years 1913 and 1916. It has not been fairly tested on maize ; it apparently does no good when applied to cotton. It appears to cause a slight increase in the yields of wheat and gram, but is inferior to lime alone in this respect. It causes little apparent increase in *toria*.

These experiments are not such as to justify the absolute negative conclusion that phosphatic manures cause no increase in these crops here ; but they certainly appear to justify the conclusion that these manures do not, under the conditions of these experiments, cause any such increases in yields as would render their use profitable.

Soluble nitrogenous manures. The results from the application of heavy dressings of these manures are very different from the results with phosphatic manures. On sugarcane and maize where the 4-ton dressings of dung applied annually caused substantial and consistent apparent increases, there these dressings of soluble nitrogeous compounds cause much greater increases in the yields. In the case of cotton, where the returns from the dung are variable, the effect of these manures varies similarly. In 1914 and 1917 when the dung only gave a slight return, then these manures gave an equal or even lesser return. In 1911, 1913, and 1917, when the dung gave more substantial returns, the returns from the soluble nitrogenous manures were generally greater still. On wheat the return from these manures is equal to, or less than, that from the farmyard manure ; and on *toria* also they roughly follow the latter but are liable to rather greater variations. On gram there is no evidence of any return from the application of these manures alone and the increases where they are used in conjunction with lime may be due to the lime.

It may be mentioned that most of the more important of these results have been confirmed by other simpler experiments in other fields under similar conditions.

Conclusions.

So far as can be seen from these experiments nitrogen is by far the most important element of plant food controlling the growth of crops grown under the conditions of these experiments. The application of nitrogenous manures to sugarcane and maize always markedly increases the yield ; but on other crops such manures do not always give the returns that would be expected on the analogy of manurial experiments in temperate climates. On cotton the results of such manuring are negligible in some years. On wheat the light dressing of farmyard manure causes a fairly consistent increase which is generally greater than that caused by the relatively heavy dressings of soluble nitrogenous manures ; on *toria* the results from the application of nitrogen in either form are considerable in favourable seasons. Gram gives little return for manuring. Lime

is apparently beneficial to gram and in a less degree to wheat; gypsum and phosphatic manures fail to give a substantial return for their application to any crop. There is reason to believe that the results of the application of nitrogenous manures depend partly on the length of the fallow period preceding the sowing of the crop.

TABLE I.

The yields of the plots treated annually with 4 tons of farmyard manure are compared to the average of the yields of the two unmanured adjacent strips (for actual yields see Table II).

"KHARIF" SERIES.

Plot No.	Sugarcane			Maize			Cotton		
6-K	1911 113·8	1913 128·2	1916	1914 Crop failed	1917 Crop failed		1912 109·2	1915 91·3	
17-K	1912 123·2	1915 141·6		1911 108·1	1913 109·0	1916 Crop failed	1914 105·3	1914 104·2	
28-K	1914 106·3	1917 127·6			1912 122·1	1915 121·8	1911 131·6	1913 114·4	1916 111·3
Average	123			115			110		

"RABI" SERIES.

Plot No.	Wheat		Toria		Gram	
6-R	1911-12 118·0	1914-15 117·4	1912-13 115·2	1915-16 159·7	1913-14 105·9	1916-17 113·0
17-R	1913-14 107·1	1916-17 114·8	1911-12 141·0	1914-15 103·4	1912-13 90·6	1915-16 98·6
28-R	1912-13 105·3	1915-16 118·7	1913-14 99·4	1916-17 126·6	1911-12 95·9	1914-15 113·6
Average	114		124		103	

TABLE II A.

No. of plot	Treatment	Area in acres	Sugarcane						Maize				Cotton			
			1911		1913		1916		1914		1917		1912		1915	
			Mds. per acre	Percentage in terms of F. Y. plot	Mds. per acre	Percentage in terms of F. Y. plot	Mds. per acre	Percentage in terms of F. Y. plot	Mds. per acre	Percentage in terms of F. Y. plot	Mds. per ac e	Percen age in terms of F. Y. plot	Mds. per acre	Percentage in terms of F. Y. plot	Mds. per acre	Percentage in terms of F. Y. plot
							Mds.		Failure		Failure					
3	Unmanured	0·056	16·1	..	28·5	..	24·9	..	..	..	..	..	4·5	..	8·6	..
4	Bonemeal at 304 lb. per acre ..	0·2	15·4	82·8	30·8	94·1	35·8	94·4	..	..	..	..	5·0	94·3	8·2	103·8
5	Unmanured	0·056	16·9	..	29·6	..	36·7	..	..	..	..	..	5·3	..	9·1	..
6	Farmyard manure at 8,960 lb. per acre.	0·2	18·6	100·0	32·7	100·0	37·9	100·0	..	..	..	..	5·3	100·0	7·9	100·0
7	Unmanured	0·056	15·8	..	21·4	..	26·3	..	..	..	..	..	4·4	..	8·2	..
8	Basic flag at 656 lb. per acre ..	0·2	29·9	112·3	23·3	71·2	29·2	77·0	..	..	..	..	4·6	86·8	8·9	112·6
9	Unmanured	0·056	21·2	..	21·4	..	29·9	..	..	..	..	..	5 6	..	7·7	..
10	Lime at 560 lb. per acre ..	0·2	17·8	95·7	21·9	66·9	26·9	70·9	..	..	..	..	5·2	98·1	5·1	64·5
11	Mean of unmanured plots ..	..	17·5	..	25·2	..	29·4	..	..	..	..	..	4·95	..	8·4	..
	P. E. of difference of two plots..	..	±1·4	..	±2·4	..	±2·9	..	..	..	..	..	±0·32	..	±0·32	..
			Sugarcane				Maize						Cotton			
			1912		1915		1911		1913		1916		1914		1917	
											Failure					
13	Calcium cyanamide at 397 lb. per acre.	0·2	25·0	122·6	31·1	97·5	33·2	124·3	41·2	128·3	..	..	6·5	94·2	12·4	100·8
14	Unmanured	0·056	12·5	..	23·6	..	30·3	..	31·2	..	..	..	4·9	..	10·7	..
15	Calcium nitrate at 550 lb. per acre.	0·2	21·0	102·9	35·6	111·6	32·1	120·2	37·2	115·8	..	..	6·1	88·4	12·1	98·3

16	Unmanured	0·056	12·5	..	30·5	..	29·8	..	24·5	..	..	..	6·2	..	11·6	..
17	Farmyard manure at 8,960 lb. per acre.	0·2	20·4	100·0	31·9	100·0	26·7	100·0	32·1	100 0	..	..	6·9	100·0	12·3	100·0
18	Unmanured	0·056	20·6	..	14·6	..	19·6	..	34·4		..	..	6·9	..	12·0	..
19	Ammonium sulphate at 318 lb. per acre.	0·2	24·4	119·6	41·5	130·9	36·9	138·2	33·7	105·0	..	..	7·6	110·1	10·1	82·1
20	Unmanured	0·056	10·2	..	23·2	..	31·2	..	23·6	..	..	..	5·8	..	11·7	..
21	Gypsum at 560 lb. per acre ..	0·2	7·3	35·8	17·7	55·5	36·9	138·2	26·4	82·2	..	..	7·2	104·3	10·8	87·8
	Mean of unmanured plots ..	..	13·9	..	22·9	..	27·7	..	28 4	..	..	..	5·95	..	11·5	..
	P. E. diffe.ence of two plots ..	..	±2·49	..	±3·58	..	±2·99	..	±2·87	..	..	..	±0·46	..	±0·31	..
			SUGARCANE				MAIZE				COTTON					
			1914		1917		1912		1915		1911		1913		1916	
24	Bonemeal at 304 lb. + lime 560 lb. per acre.	0·2	15·0	147·0	26·2	92·2	27·9	102·9	25·1	112·6	7·0	89·7	8·9	107·2	10·3	87·3
25	Unmanured	0·056	10·2	..	23·4	..	26·2	..	19·3	..	6·9	..	9·6	..	10·7	..
26	Ammonium sulphate 318 lb. + lime 560 lb. per acre.	0·2	17·5	171·5	38·8	136·6	33·9	125·1	23·4	104·9	10·1	129·4	9·6	115·6	13·4	113·5
27	Unmanured	0·056	10·7	..	20·9	..	23·3	..	17 0	..	6·45	..	7·0	..	10·5	..
28	Farmyard manure at 8,960 lb. per acre.	0·2	10·2	100·0	28·4	100·0	27·1	100·0	22·3	100·0	7·8	100·0	8·3	100·0	11·8	100·0
29	Unmanured	0·056	8·5	..	23·6	..	21 9	..	19·6	..	5·4	..	7·5	..	10·7	..
30	Bonemeal 304 lb. + lime 560 lb. and ammonium sulphate 318 lb. per acre.	0·2	14·7	144·1	39·4	138·7	36·2	133·5	26·2	117·4	10·7	137·2	10·6	127·7	16·6	140·6
31	Unmanured	0·056	6·7	..	15·6	..	25·5	..	17·8		8·2	..	7·8	..	13·4	..
32	Superphosphate 231 lb. + calcium nitrate 450 lb. + ammonium sulphate 318 lb. per acre.	0·2	14·7	144·1	38·2	134·5	30·4	112·1	26·9	120·6	10·7	137·2	10·2	122·9	18·9	160·1
33	Unmanured	0·056	5·3	..	16·9	..	25·9	..	22·4	..	7·1	..	6·6	..	12·1	..
	Mean of unmanured plots ..	..	8·3	..	20·1	..	24·3	..	19·2	..	6·8	..	7·7	..	11·5	..
	P. E. of difference of two plots	..	±1·08	..	±1·75	..	±0·98	..	±0·98	..	±0·48	..	+0·55	7·1	+0·59	..

TABLE II B.

No. of plot	Treatment	Area per acre	Wheat				Toria				Gram			
			1911-12		1914-15		1912-13		1915-16		1913-14		1916-17	
			Mds. per acre	Percentage in terms of F. Y. plot	Mds. per acre	Percentage in terms of F. Y. plot	Mds. per acre	Percentage in terms of F. Y. plot	Mds. per acre	Percentage in terms of F. Y. plot	Mds. per acre	Percentage in terms of F. Y. plot	Mds. per acre	Percentage in terms of F. Y. plot
3	Unmanured	0·056	22·7	..	14·2	..	15·6	..	7·2	..	15·1	..	17·6	..
4	Bonemeal at 304 lb. per acre	0·2	25·4	95·8	15·9	90·8	14·5	100·7	9·8	82·3	17·1	96·6	18·4	90·2
5	Unmanured	0·056	20·0	..	14·7	..	13·4	..	7·3	..	16·0	..	18·3	..
6	Farmyard manure at 8,960 lb. per acre ..	0·2	26·5	100·0	17·5	100·0	14·4	100·0	11·9	100·0	17·7	100·0	20·4	100·0
7	Unmanured	0·056	24·9	..	15·1	..	11·6	..	7·6	..	17·4	..	17·8	..
8	Basic slag at 656 lb. per acre	0·2	26·7	100·7	17·6	100·6	13·4	93·0	9·2	77·3	17·1	96·6	20·9	102·4
9	Unmanured	0·056	21·4	..	16·5	..	13·8	..	6·7	..	16·9	..	18·3	..
10	Lime at 560 lb. per acre	0·2	28·1	106·0	20·6	117·7	13·2	91·6	5·4	45·4	22·0	124·3	24·0	117·6
	Mean of unmanured plots	..	22·3	..	15·1	..	13·6	..	7·2	..	16·3	..	18·0	..
	P. E. difference of two plots	..	±1·14	..	±0·54	..	±0·90	..	±0·21	..	±0·55	..	±0·22	..
			1913-14		1916-17		1911-12		1914-15		1912-13		1915-16	
13	Calcium cyanamide at 396·7 lb. per acre ..	0·2	19·7	94·2	25·0	92·2	22·7	93·0	6·6	86·8	20·9	81·6	21·8	99·0
14	Unmanured	0·056	20·0	..	27·4.	..	17·8	..	5·3	..	22·3	..	19·8	..
15	Calcium nitrate at 550 lb. per acre ..	0·2	20·1	96·1	27·9	102·9	18·7	76·6	6·5	85·5	23·9	93·7	23·6	107·2
16	Unmanured	0·056	21·8	..	23·2	..	14·7	..	5·8	..	27·6	..	22·8	..

17	Farmyard manure at 8,960 lb. per acre ..	0·2	20·9	100·0	27·1	100·0	24·4	100·0	7·6	100·0	25·6	100·0	22·0	100·0
18	Unmanured	0·056	17·2	..	24·0	..	19·9	..	8·9	..	28·9	..	21·8	..
19	Ammonium sulphate 318 lb. per acre ..	0·2	17·9	85·6	23·2	85·6	22·0	90·1	7·4	97·3	26 2	102·3	20·1	91·3
20	Unmanured	0·056	18·3	..	24·5	..	12·5	..	5·3	..	27·6	..	21·3	..
21	Gypsum at 560 lb. per acre	0·2	18·7	89·4	25·0	92·2	15·2	62·3	5·0	65·8	25·7	100·4	20·6	93·8
	Mean of unmanured plots	..	19·3	..	24·8	..	16·2	..	6·3	..	26·6	..	21 4	..
	P. E. difference of two plots	..	±1·10	..	±1·00	..	±1·79	..	±0·94	..	±1·60	..	±0·66	..
			1912-13		1915-16		1913-14		1916-17		1911-12		1914-15	
24	Bonemeal 304 lb. / Lime 560 lb. } per acre ..	0·2	29·1	113·2	25·1	95·1	8·7	102·3	12·3	84·8	20·4	142·6	19·7	110·1
25	Unmanured	0·056	24·5	..	21·4	..	8·1	..	9·8	..	16·1	..	16·0	..
26	Lime 560 lb. / Ammonium sulphate 318 lb. } per acre ..	0·2	25·6	99·6	26·7	101·1	12·7	149·4	16·7	115·1	16·7	116·7	18·4	102·8
27	Unmanured	0·056	22·5	..	22·7	..	7·3	..	10·2	..	12·9	..	15·9	..
28	Farmyard manure at 8,960 lb. per acre ..	0·2	25·7	100·0	26·4	100·0	8·5	100·0	14·5	100·0	14·3	100·0	17·9	100·0
29	Unmanured	0·056	26·3	..	21·8	..	9·8	..	12·7	..	16·9	..	15·6	..
30	Bonemeal 304 lb. + lime 560 lb. + ammonium sulphate 318 lb. per acre.	0·2	26·1	101·5	25·3	95·8	13·4	157·6	18·1	124·8	16·5	115·4	17·5	97·7
31	Unmanured	0·056	26·8	..	20·9	..	11·5	..	14·9	..	17·4	..	12·0	..
32	Superphosphate 231 lb. + calcium nitrate 550 lb. + ammonium sulphate 318 lb. per acre.	0·2	19·1	74·3	23·6	89·4	15·7	184·7	18·9	130·3	16·0	111·9	16·2	90·5
33	Unmanured	0·056	24·5	..	24·5	..	8·9	..	16·9	..	..	..	12·9	..
	Mean of unmanured plots	..	24·9	..	22·3	..	9·1	..	12·9	..	15·8	..	14·5	..
	P. E. difference of two plots	..	±0·80	..	±0·67	..	±0·76	..	±1·14	..	±1·11	..	±0·89	..

Notes

THE BOARD OF AGRICULTURE IN INDIA.

THE Twelfth Meeting of the Board of Agriculture in India will be held at Pusa from the 13th to the 18th February, 1922, when the following subjects will be discussed :—

I. The line of demarcation between Agriculture and Industries as affecting the work of the departments concerned.

II. Further discussion regarding measures for famine relief.

III. The examination of the proposal to prohibit the export of certain manures from India.

IV. Subjects connected with cattle breeding.

V. Motor tractor cultivation. For what particular purposes motor tractors may prove useful in India and the best means for arriving at suitable types of both tractors and implements for the various requirements.

VI. Manufacture of nitrogen fixation products in India.

VII. Need for the study of the movements of nitrates in soils.

VIII. The improvement of the potato crop in India with special reference to the seed supply for the plains.

IX. Discussion on the resolution passed by the last Sectional Meeting of Chemists and Bacteriologists regarding measures to be adopted to secure continuity of field experiments of a permanent nature.

X. Agricultural Middle Schools. A discussion on the progress made and experience gained in the provinces.

XI. Whether biennial Sectional Meetings of (1) Botanists, (2) Agriculturists and Agricultural Engineers are advisable.

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GREEN-MANURING OF BROADCASTED PADDY IN ORISSA.

It is generally recognized by the cultivators that if fields are green-manured with *dhaincha* (*Sesbania aculeata*) and then transplanted with paddy the yield is thereby increased. But owing to various causes transplanting of paddy is not practised in Orissa to a very large extent; hence the advantage of green-manuring is not utilized. It was therefore decided to devise means, if possible, of green-manuring broadcasted paddy, broadcasting being the usual practice. With this view experiments were started in 1915 in the Cuttack farm and continued for three years with the result that green-manuring of broadcasted paddy was found possible and profitable which gave an average excess yield of 3 maunds and 7 seers (1 maund = 40 seers = 82 lb.) of grain per acre. The practice is very simple which consists in sowing a certain quantity of *dhaincha* seeds with the paddy and burying the *dhaincha* plants in the soil at the time of *beushaning*. This practice of *beushaning* consists in ploughing through the field when the crop is about a month or six weeks old, the object being to reduce the cost of weeding and to promote tillering. Indirectly perhaps it serves the same purpose as transplanting though in a clumsy way, and also to a certain extent the purpose of green-manuring, for most of the weeds and about half the number of the paddy plants are buried in the soil in this process. It is an universal practice in Orissa in the cultivation of broadcasted winter paddy and no cultivator would omit it; hence it affords an admirable opportunity of combining green-manuring with broadcasting.

As the above experiments were conducted on small areas it was decided in 1920 to carry out the same experiment on a field scale and for that purpose nearly eight acres of similar land was divided into two plots of nearly four acres each. In one of them paddy seeds were broadcasted at the rate of 30 seers per acre. In the other, 7½

seers of *dhaincha* seeds were mixed with 30 seers of paddy seeds per acre and broadcasted. At first the plot in which only paddy seeds were broadcasted looked very well while the plot in which *dhaincha* and paddy seeds were broadcasted looked as if the paddy seedlings were going to be completely destroyed by the overgrowing *dhaincha* plants. At the time of *beushaning* the *dhaincha* plants were buried in the soil. From this time onward the paddy plants in the plot which had the *dhaincha* began to look healthier, and when the crop was harvested and weighed it was found that the plot which was treated with *dhaincha* gave an yield of 2 maunds and 14 seers of paddy per acre in excess over the plot which was not so treated. All the operations were similar in both the plots. Most of the *dhaincha* plants were buried in the soil in *beushaning*; the extra cost of burying those which were not buried in that process was counter-balanced by the smaller cost of weeding as the *dhaincha* plants prevented the growth of weeds. This is a simple process which can be practised by any cultivator. The only extra cost involved in the operation is the price of *dhaincha* seeds. But every cultivator can grow a few *dhaincha* plants in the odd corners of his field or along the *ails* and thus save the cost of seeds. The rate of *dhaincha* seeds which may be mixed with paddy seeds may vary from 5 to 7½ seers per acre. The rate of paddy seeds may also vary from 30 to 40 seers per acre. [S. K. Basu.]

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GINNING PERCENTAGE OF COTTON IN ITS RELATION TO SEASON.

In vol. XV, pt. V, of this Journal, Mr. Thompstone published a note on the ginning percentage of cotton in its relation to season, and enquired what had been the experience of others. The observations made by the writer indicate that the ginning percentages have a bearing on season in Khandesh also. The shorter the rainfall, the lower the ginning percentage; and normal the rainfall, the nearer it is to the average. This fact has been observed at Dhulia and Jalgaon farms in West and East Khandesh where *neglectums* are grown. Dhulia has got an average rainfall varying from 18-20 inches and Jalgaon about 28 inches. The following statement

summarizes the observations for three seasons at Jalgaon and two seasons at Dhulia :—

Name of variety	Ginning percentage in different years at Jalgaon Farm			Ginning percentage in different years at Dhulia farm	
	1918-19	1919-20	1920-21	1910-11	1912-13
G. neglectum rosea	36·75	37·50	36·71	37·4	33·49
G. neglectum rosea cutchica	38·25	40·25	38·30	36·3	31·75
G. neglectum vera	31·50	33·68	32·87	27·1	24·62
G. neglectum vera malvensis	29·70	32·18	30·87	25·1	23·10
RAINFALL IN INCHES	15·94	33·17	13·53	32·51	9·96

At Jalgaon the ginning percentage fell in the year of scarcity from 0·75 per cent. to nearly 2 per cent. and at Dhulia from 2 to 5 per cent. [B. P. VAGHOLKAR.]

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COST OF PRODUCING COTTON IN U. S. A.

THE U. S. A. Department of Agriculture Bulletin 896 of 1920, on " Cost of Producing Cotton ", deals with the results of an examination of the cost of cotton growing on 842 farms representing ten districts in the Cotton Belt, and relates to the crop year 1918. It is calculated that the average cost of producing cotton in 1918 was 23 cents per pound—varying from 8 cents to 107 cents—but on the bulk of farms the cost of production was below 28 cents. The average price received by farmers for their 1918 cotton estimated at 29 cents per pound, and 80 per cent. of the cotton was sold at prices between 25 and 32 cents, the extreme range being from 20 to 43 cents. [B. C. BURT.]

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EARLY ARROWING OF SUGARCANE.

IN view of the general interest of the subject, we reprint from " Sugar " the following note on " the premature going to flower of the sugarcane " :—

" Different theories have been advanced as to the causes and effects of the premature going to flower of the sugarcane. According

to some, this depends on the method of planting; according to others the cause must be sought in insufficient nutrition, lack of fertilizer, and any other factor that slackens or retards the development of the cane; while, according to another theory, the flowering is hastened by an active growth, and especially by an excess of nitrate. However, none of these theories can explain the different circumstances observed in the case of prematurely flowering canes.

"De Grobert now gives, in the 'Bulletin de l' Association des Chimistes de France,' the observations of Labarthe, who came to the conclusion that the premature flowering of the cane is due to a disproportion between the amount of water absorbed by the roots and that given off by the leaves. It follows that the flowering is favoured by all factors that either increase the absorption of water by the roots, or decrease the number or activity of the evaporating parts of the plant. When, at the beginning of summer, the moisture of the soil decreases, while the temperature of the air increases, the warm wind blows, or when the contents of the air in water-vapour change rapidly, the layer of cells forming the surface of the leaves becomes thicker, the openings become smaller and less in number, and the evaporation is insufficient. The growth of the cane then becomes slower, and the tendency to flower appears as the plant adapts itself to new evaporating conditions.

"In these conditions, planters at times endeavour to remedy the evil by irrigation, but this can have a favourable or an unfavourable effect, according to the development of the roots. When the soil is poor in nitrogen the roots are strong, they absorb the water in larger amounts, and the formation of flowers is hastened; while in the case of soils rich in nitrogen, the roots are not much extended, the absorption of water is smaller, and the growth becomes again normal, that is to say, new leaves are formed.

"In investigating the effect of an excess of moisture on the development of the flowers, due to rise of the water level in the soil, or to strong rains, etc., Labarthe came to the surprising conclusion that too much moisture in the soil favours the flowering, and that this favourable influence is stronger in the case of much developed roots.

This last remark does not agree with the other conclusions of Labarthe and calls for additional researches.

" Regarding the effect of the flowering on the composition of the cane, Boname had stated that the sugar contents of the cane remain stationary from the moment of appearance of the flowers, while Vanderghem, confirming the statement of Boname, added that canes going to flower contain less juice. Labarthe found that canes gone to flower contain a juice poorer in sucrose and richer in glucose.* The weight of the crop is less, and as it contains less juice, the yield is also smaller. Labarthe, who carried out his tests in Peru, concluded that the Bourbon cane is less given to flowering, that the planting should be close, good nitrogen fertilizers should be provided and the irrigation should be kept within limits. De Grobert considers it of interest to investigate whether the causes discovered by Labarthe do not also apply in the case of beets going to flower."

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SUGAR TARIFF IN THE UNITED STATES OF AMERICA.

" THE West India Committee Circular," dated the 21st July, 1921, has the following note on the proposed tariff legislation in the United States of America:—

" The Permanent Tariff Revision Bill, introduced into the United States House of Representatives on June 29th last, is an extremely important measure, inasmuch as it shows a tendency on the part of America to modify to a considerable extent the fiscal attitude towards other countries which has characterized it of recent years. This is seen in the provisions which have been introduced into the Bill at President Harding's request to enable the President of the United States to adjust tariff rates with foreign countries, giving reciprocal trade advantages to the extent of 20 per cent. of the existing duties, or to enter into commercial treaties, when

* This does not agree with the conclusion arrived at by other observers. As Dr. Barber points out in his review of the paper in the *International Sugar Journal*, August 1921, in most cases other observers have come to the conclusion that once the flowering stage has set in, the juices remain more or less constant : growth however ceases and there is less of it but the juice may even be richer in sucrose than in those plants which continue their growth uninterruptedly. [K. D. N.]

ratified by the Senate and approved of by Congress, placing the natural products of any country on her free list. As regards sugar, although the Bill contains the same tariff as that in the Emergency Tariff recently passed, it contains an important addition in the shape of the following clause :—

"'Any person manufacturing or refining in the United States sugar, testing by the polariscope over ninety-nine degrees, produced from beet or cane grown in the continental United States, shall for each pound so manufactured or refined during any month in any State, Territory, or the District of Columbia, be permitted to import, at any time before the expiration of nine months after the last day of such month (for the sole purpose of being manufactured or refined by him in such State, Territory or District), two pounds of sugar testing by the polariscope not above ninety-six degrees, at three-fourths the rate of duty to which such sugar would otherwise be subject.'

"The present domestic sugar production of the United States is about 1,100,000 tons, and the clause opens up the possibility of 2,200,000 tons of refining sugar being introduced at a relatively low rate of duty. The object of the clause is primarily to develop the domestic sugar production by cheapening the cost of production through enabling the factories to be used all the year round. Last year's crop consisted of 156,000 tons of cane sugar from Louisiana and Texas, and 960,000 tons of beet-sugar from the Western States. The sub-tropical cane industry of the first named States does not admit of much in the way of expansion ; consequently, the effect of the clause, should it come into operation, will be to give a substantial stimulus to the already considerable beet-sugar industry, for which large and suitable areas exist. It will be the old story of the competition between beet-sugar and cane-sugar, with the venue changed from the Old World to the New. A secondary purpose indicated in the clause is that of the development of the manufacture of high class direct consumption sugars without the aid of the refiner."

It will be seen from the above that the discrimination shown to manufacturers or refiners of home-grown sugar permitting them to

import double the quantity of raw sugar at a lower rate of duty will enable them to work all the year round and will result in reducing their overhead charges per ton of sugar manufactured or refined, thereby cheapening the cost of production and so strengthening their position. It is, however, obvious that this principle is of value only where the import duty is *quantitative* and not *ad valorem*. [KASANJI D. NAIK.]

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LOUISIANA SEEDLING CANE NO. 511.

IN the Report of the Louisiana Agricultural Station for 1920, it is stated that the juice from the L511 seedling contained 14·75 per cent. of sucrose as compared with 12 per cent. for D74 and 11·75 for the "purple" cane. This seedling also showed a marked resistance to the mosaic disease. It should be remembered that, on account of the short period possible for growth, only nine months in Louisiana, the cane juice there has always a comparatively low sugar content. Should L511 continue its promise, it should prove of great benefit to the Louisiana industry.

This variety was imported in India at the Cane Breeding Station, Coimbatore, as early as 1916, chiefly for the qualities of early ripening and high sucrose content, but its germination and growth have so far been thoroughly unsatisfactory there.

Fiji B, however, behaved in the same manner at first but has subsequently been found to be a very good cane for South India. Further trials would therefore seem necessary before condemning L511 as unsuitable for any part of India. [KASANJI D. NAIK.]

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SOILS OF CUBA.

IN view of the position of supreme importance which Cuba has attained during recent years as the largest producer of sugar (nearly 4,000,000 tons) in the world, any information on the condition of the soils in the various parts of Cuba will probably be of interest to many readers of "The Agricultural Journal of India." We, therefore, make no apology for reproducing in extenso the following extract on the subject from "The Cuba Review" of May 1921:—

"There is no doubt that the almost universal impression among those not familiar with the details of Cuba's agriculture is that her soils are rich beyond imagination, and that, as a consequence, the use of fertilizers would be superfluous. There is no doubt also that, broadly speaking, there was a period in Cuba's history when by far the largest part of her area was covered with immense virgin tropical forest, and that at that time the use of fertilizer or even that of cultivation in order to further the growth of crops was non-essential. Even yet there are to be found in various parts of the Island, especially in the three eastern provinces, Santa Clara, Camaguey and Oriente, areas of land covered with the virgin forest which met the view of Columbus as he sailed along the Island's northern shore, and here, when these lands are cleared of the timber and small growth covering them and are planted to cane or other of our crops, the use of fertilizer is unnecessary and years pass by without their becoming impoverished. But in the three western provinces, Matanzas, Havana and Pinar del Rio, and also in many parts of the province of Santa Clara and in some of the older parts of Camaguey and Oriente Provinces, cultivation of the same crop, sugarcane, has been carried on continuously for so very many years without the return to the soil of the plant food removed therefrom by the crops grown thereon, that the use of fertilizers and of the more modern and careful agricultural practices connected therewith are imperative, if reasonably abundant returns are desired from the labour put forth.

"It is also a fact that scattered throughout the Island practically in all provinces, but especially occurring in the central portion of Camaguey Province, the east-central of Santa Clara Province, the west-central of Matanzas Province, and in a very large area in the central and western portions of Pinar del Rio Province, there are found large bodies of land which apparently have never been covered by forest and whose fertility has always been very much lower than that of the wooded areas surrounding and adjacent to them. In the periods of ordinary agricultural activity in Cuba, these areas of soil have been avoided by the native agriculturist, but in periods of great profit from certain crops, small portions of these areas have

been utilized, advantage being taken of the benefits to be derived from manuring; and the gradual improvement through cultivation and manuring have transformed considerable bodies of these one time useless lands into soils of moderate fertility which respond bounteously to proper agricultural treatment. Especially has this been the case in the tobacco lands of central and western Pinar del Rio Province, where the small farms on which the tobacco has been grown have gradually extended in area through the gradual improvement of the lands immediately surrounding the small wooded areas where tobacco was originally planted and where the finest quality of leaf is still produced. It is also true that considerable areas of the light, red, porous "savannah" of Matanzas Province have been rendered valuable through the use thereon of high grade fertilizers in abundance, so that during the last two or three years of high or acceptable sugar prices the profits taken from these not long ago 'worthless' soils have been great.

"That proper conclusions may be arrived at by the investigator into the possibilities of the fertilizer industry in Cuba, a résumé of the soil characteristics found in the various provinces of the Island will be helpful. In Pinar del Rio Province, in the extreme western portion, is found a small body of red land, in places a sandy loam, in others a heavier clay underlaid with limestone, which in many places appears above the surface as the well known 'dog-tooth' rock formation so prevalent in many localities in Cuba. The lighter of these soils have been devoted for many years to tobacco growing, and have proved to be excellently adapted to the production of Irish potatoes, onions and other vegetables, and the use of fertilizer on all these crops has proved profitable. Irrigation water can be obtained in great abundance and at no great depth, so that the conditions for growth of these crops during the dry season are favourable. To the east of the Cuyaguateje river are found very large areas of true sandy loams, in all of which the use of fertilizer is essential in order that profitable crops be secured. To the north of the mountain range, extending practically whole length of the province and to the south of the central plain in which the sandy loams just referred to occur, are found large areas of black heavy

clay soils, very fertile in their original state, now in places exhausted on account of the loss of the organic matter originally held by them, on which the use of fertilizers has not conclusively shown profit. Farther east in the central portion of the province and extending into Havana and Matanzas Provinces, are large areas of red soil of two classes, one a heavy clay, the other a lighter pervious clay, both varying in depth from only a few inches overlying the limestone to a great many feet, both extremely productive in their original condition and even to-day, under the proper use of irrigating water, capable of producing, even without fertilizer, very acceptable crops. On the heavier of these red clays, the use of fertilizer has frequently been shown to be profitable, but as frequently the increase in the crop due to the fertilizer has not offset its cost; but on the rather more pervious red soils, known in Cuba as 'terreno colorado de polvillo,' failure to obtain profitable results from the use of fertilizer accompanied by normal care in cultivation has been very rare, and can be traced usually to the faults of the agriculturist himself. Interspersed throughout these large areas of red land are found quite large bodies of soils of heavier type and of colours varying from a deep black through brown to yellow on which the profitable use of fertilizer is a question of locality, as only by experiments carried out on individual farms can the advisability of the use of fertilizer in each farm be ascertained.

"The province of Santa Clara generally consists of more virgin soils than those being farmed in the three western provinces. In the western portion of this province occur considerable bodies of the red soils which we have just mentioned, and these respond abundantly and surely to the use of fertilizer; but there are also found in this province very large areas of land, some of which have been under continuous cultivation for a great many years, and in which, due to their physical characteristics, the use of the ordinary commercial fertilizer has been shown to be unprofitable. These soils are uniformly of a very heavy type, are usually underlaid by a rather impervious clay, and through the many years of cultivation without the return to them of the organic matter which has been removed from them, have become inert mineral masses, the improvement of

which is possible only through the mingling with them of large quantities of coarse materials such as the refuse of our filter presses 'cachaza,' stable manure, and the ploughing under of several leguminous crops. Even after this is done, these soils go back very rapidly to the condition in which they were found before this improving treatment, and it is generally acknowledged that about the only method to obtain fairly satisfactory results from their use is to prepare them thoroughly and after planting to give them the very best of cultivation. In the central portion of this province there is found quite an area of rather heavy sandy clay soils, very poor and lacking in drainage, on which the use of fertilizers accompanied by the proper agricultural methods has given good results.

"Camaguey Province varies in soil characteristics perhaps as much, if not more than any other province of the Island. Here lines of transportation have been established only within the last few years, so that five years ago there was a vast forest area occupying her northern shores, and there is still to-day a similar large forest area covering the lands between the Cuba Railroad and the south shore, broken only where plantings have been made for the sugar mills established to the east of Ciego de Avila during the last three or four years of high sugar prices. In the extreme western portion of the province and extending to the east of Ciego de Avila, and pretty well along the entire north coast between Moron and the Maximo river, is found a body of red land in many places of great depth of wonderful original fertility, but which is already beginning to feel the need of fertilizers and on which these can be and are being used with profitable results. Similarly, in the lighter lands of the central plain, there are considerable areas on which the use of fertilizers is commercially profitable.

"Only Oriente Province is left to be considered. As a whole the province is very new from an agricultural standpoint. In the Guantanamo district, however, quite a number of sugar mills are located within a limited area, compelling their owners to make the most intense use possible of the lands subject to their control, with the result that here the fertility of the soil has been greatly reduced

and the necessity for restoring to it the plant foods removed has been recognized for some time, and we understand that quite satisfactory results have been obtained from the use of fertilizers in particular classes of the soil in the Guantanamo Valley. However, it is doubtful whether the use of fertilizers on 90 per cent. of the soils of this province will ever prove profitable, as they consist mostly of the heavy black types underlaid at no great depth with a more or less impervious clay, which have resisted all attempts to improve their crops through the application of fertilizers.

"From the above, a brief summary indicates that the areas of land which respond to the proper use of fertilizers are as follows :— A large portion of the province of Pinar del Rio, especially south and east of the mountain range ; a considerable area in Havana Province, this consisting mostly of the lighter type of red soil ; a very large percentage of the province of Matanzas, consisting also of varying qualities of red soil ; a considerable area in the western portion of Santa Clara Province, and a small area in the central portion thereof ; similarly a considerable area in the western portion of Camaguey Province, some small areas along the north coast near and to the west of La Gloria, and an area of considerable size in the central plain of this province ; and in the Guantanamo Valley a small area of lands long devoted to the cultivation of sugarcane."

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A VAST COTTON-GROWING PROJECT.

"THE New York Times" recently published an article of unusual interest from the pen of Mr. Arnold Krukman, Secretary to the League of the South-West, on the reclamation of three million acres of desert land in New Mexico, Arizona, California, Nevada, Colorado, Utah and Wyoming. It will involve the harnessing of the Colorado river now flowing for 1,200 miles through a series of chasms of which the best known is the Grand Canyon. It is proposed to build a huge dam at Boulder Canyon to irrigate this vast area which is the only section of North America suited to the growth of long-staple cotton, such as is now grown in Egypt and the Soudan. This is the fibre used in the cloth for covering airplanes and for motor tyres. The

dam will enclose a volume of water equal to the entire flow of the river for two years. The engineers in the United States have already a wide experience in works of this kind, and we may look forward with confidence to the accomplishment of the work and to the effects it will have on the markets both for cotton and for labour. The United States has already reduced the average of land usually placed under cotton, partly owing to the ravages of the bollworm and partly to the difficulty of procuring labour in the picking season. This latter is at times so acute as to call for the aid of all the day schools to make up a sufficient picking staff. Wages, of course, mount on such occasions. The cotton-picking machine, that has cost such large sums in experiments and has so often seemed to have overcome all difficulties, is still elusive and awaits the arrival of a fresh and original brain that, after careful study of the problems in the field, can strike the happy medium between the work as shared by the human intelligence directing the machine and the mechanism doing the work. If the crop were ripe all on one day and the field could be picked bare at one pass like a wheatfield, the problem would be simplified. But this is not the case. In the season of 1920-21, according to the report of the Shepperson Company, the acreage under cotton in the United States was 35,504,000. An addition of 3 million acres would be equal to nearly 8½ per cent. so that the labour supply question may become more acute than ever, especially as the collection of the crop represents only a seasonal demand. [*The Indian Textile Journal*, XXXI, no. 370.]

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UTILIZATION OF COTTON STALKS.

An interesting article in " The Bulletin of the Imperial Institute" (XIX, 1,) deals with the problem of the commercial utilization, in cotton-growing countries, of the vast quantities of cotton stalks which are produced each year and have to be removed from the fields after the cotton crop has been gathered. Investigation at the Imperial Institute has shown that the stalks form a promising material for paper-making and that they might also be used for obtaining acetic acid, tar and charcoal by a process of dry distillation.

CALCIUM MALATE FROM WASTE APPLES.

SOME time ago, writes the United States Consul at Yarmouth (Nova Scotia), there appeared in the columns of a local newspaper an article on the discovery at Annapolis of a method of extracting by-products from waste and otherwise useless apples. A further press report has now appeared, which states that it has been found that even the most intensely acid and usually worthless apple may be so treated by a simple process as to yield syrup which has been pronounced eminently desirable as a basis for other concoctions not hitherto so well supplied. And not only is this syrup valuable, but another by-product has become evident in deposits of calcium malate, the same article as is derived from maple syrup and known as sugar sand. Before the war, the Germans bought this up extensively in Quebec at $1·50 or more per pound as a source of malic acid. The process is being carried on in two evaporators and may lead to the development of an entirely new industry in Nova Scotia. The Consul adds that experiments are still going on, but that at present no further details will be made public. [*Journal of the Royal Society of Arts*, 3586.]

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IMPORTATION OF PLANTS INTO THE UNITED KINGDOM.

THE British Ministry of Agriculture and Fisheries has issued a Destructive Insects and Pests Order to ensure that only healthy plants are imported into the country. The Order, which comes into force from 1st October, 1921, prohibits the landing in England and Wales, from countries outside the British Isles and the Channel Islands, of all living plants with a persistent woody stem above ground, and parts of the same, except seeds, when for use in propagation such as fruit trees, stocks and stools, forest trees, and ornamental shrubs and grafts, layers and cuttings thereof; all potatoes; tubers, bulbs, rhizomes, corns and hop stocks for planting; seeds of onions and of leeks for sowing; and gooseberries; unless each package thereof has attached thereto, or is accompanied by a copy of a certificate issued at the time of packing by a duly authorized official of the country from which it is exported, to the

effect that the consignment is healthy and free from injurious insects and pests. In the case of potatoes the certificate must also declare that "Wart" disease has not occurred on the place where the potatoes were grown, nor within 500 yards thereof, except in the case of new potatoes.

The inspection must be made not more than 30 days prior to the date of despatch, and the certificate must state that the plants, seeds, etc., are healthy as regards common pests generally and particularly the following :—

Fruit Tree Cankers (produced by *Nectria ditissima*, Tul. or any species of Monilia).

Silver Leaf (*Stereum purpureum*, Pers.).

Black Currant Mite (*Eriophyes ribis*, Nal.).

Woolly Aphis (*Eriosoma lanigerum*, Hausm.).

All Scale Insects (Coccidæ).

Brown Tail Moth (*Nygmia phœorrhœa*, Dan. (*Euproctis chrysorrhœa*).

Rhododendron Fly (*Leptobyrsa* (*Stephanitis*) *rhododendri*, Horv.).

Potato Blackleg (*Bacillus atrosepticus*, Van Hall).

American Gooseberry Mildew (*Sphœrotheca mors-uvæ*, (Schw.) Bk. et Curt.).

And also that they are free from the insects and pests specified below :—

Fungi.

Black Knot of Plum and Cherry (*Plowrightia morbosa*, Sacc.).

Pear Blight (*Bacillus amylovorus*, De Toni.).

Chestnut Canker (*Endothia parasitica*, (Murr.) Ander and Ander.).

Wart Disease of Potatoes (*Synchytrium endobioticum*, Perc.).

Onion and Leek Smut (*Urocystis Cepulæ*, Frost).

Downy Mildew of Hops. (*Peronoplasmopara humulim*, Miy. et Taka.).

Insects.

Vine Louse (*Phylloxera vastatrix*, Planch.).

American Apple Capsids (*Heterocordylus malinus*, Reut. and *Lygidea mendax*, Reut.).

Pear Tingid (*Stephanitis pyri*, Fab.).

Colorado Beetle (*Leptinotarsa decemlineata*, Say.).

Plum Curculio (*Conotrachelus nenuphar*, Herbst.).

Potato Moth (*Phthorimæa operculella*, Zell.).

American Lackey Moths (*Malacosoma americana*, Fab., and *M. disstria*, Hubn.).

Oriental Fruit Moth (*Cydia molesta*, Busck.).

San Jose Scale (*Aspidiotus perniciosus*, Comst.).

Japanese Fruit Scale (*Diaspis pentagona*, Newst.).

Apple Fruit Fly (*Rhagoletis pomonella*, Welsh).

Cherry Fruit Flies (*Rhagoletis cerasi*, Linn., *R. cingulata*, Loew., and *R. fausta*, Osten Saken).

Gooseberry Fruit Fly (*Epochra canadensis*, Loew.).

The certificate should be forwarded to the "Horticulture Division, Ministry of Agriculture and Fisheries, Whitehall Place, London, S.W.1," at the time of issue, and a copy affixed to each package in the consignment.

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INHERITANCE OF QUANTITY AND QUALITY OF MILK PRODUCTION IN DAIRY COWS.

[CASTLE, W. E., in the *Proceedings of the National Academy of Sciences of the United States of America*, vol. V, no. 10, pp. 428–434. Washington, October 1919.]

In 1911, Mr. T. J. Bowlker undertook, at his farm in Framingham (Massachusetts), an experimental study on a large scale of inheritance in dairy cows by the modern method of crossing pure breeds and looking for a combination, in the 2nd cross-bred generation, of the characters differentiating the breeds used in crossing. The breeds which he selected for trial were the Holstein-Friesian (which surpasses all others in the quantity of milk produced) and the Guernsey, which is distinguished for the quality of its milk. He started with the idea that, if the quantity and quality of milk production were independently inherited characters, it should be

possible to combine them in a single breed by cross-breeding, in accordance with Mendel's laws. The experiments were continued at Framingham up to 1919, and will be carried on by the University of Illinois.

The Holstein cows were mated with a Guernsey bull and the Guernsey cows with a Holstein bull. Altogether, between 1912 and 1919, 140 F_1 calves were produced; by mating F_1 bulls, 35 living F_2 calves were obtained, all vigorous and well grown. The F_1 cows calved for the first time at a slightly earlier age than the cows of either pure breed, which is evidence of their vigour and early maturity.

The following data have been taken from the tables shoiwng the milk and butter-fat production for the 1st and 2nd lactation periods of the pure bred cows and of those cross-bred:—

Milk and butter-fat production of cows of pure Holstein and Guernsey breeds and of cows bred by crossing them.

Breed	Number of cows	Average age at calving	Average quantity of milk produced	Percentage of butter-fat	Average quantity of butter-fat produced
		1st lactation period.			
		years	lb.		lb.
Holstein*	25	2·8	7,673	3·4	261
Guernsey	8	2·7	4,617	5·0	230
F_1 cross-bred	31	2·6	6,612	4·08	270
		2nd lactation period.			
		years	lb.		lb.
Holstein	20	4	9,475	..	322
Guernsey	8	3·8	5,593	..	280
F_1 cross-bred	13	3·9	8,663	..	363

In the 1st lactation period, and still more in the 2nd, the F_1 cross-bred cows gave results superior to the mean between the results given by the pure breeds producing them both as regard

the quantity of milk and fat. But the record of variations relatively to the mean in the case of F_2 cross-bred cows must be awaited, unless the quality and the quantity of milk production are transmitted by independent factors; in that case it should be possible to combine them and to obtain inheritance transmission.

The two reciprocal crosses differed very slightly, and inversely in the two lactation periods; it seems, therefore, unlikely that any sex-linked factors are concerned. [*International Review of the Science and Practice of Agriculture*, February 1920.]

PERSONAL NOTES, APPOINTMENTS AND TRANSFERS, MEETINGS AND CONFERENCES, ETC.

MR. B. C. BURT, M.B.E., B.Sc., F.C.S., Secretary, Indian Central Cotton Committee, Bombay, made over charge of the current duties of his office to the Agricultural Adviser to the Government of India on the 19th August, 1921, and proceeded to England on deputation.

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MR. M. WYNNE SAYER, B.A., Secretary, Sugar Bureau, was on privilege leave for two months from the 25th August, 1921.

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MR. J. F. DASTUR, M.Sc., Offg. Second Imperial Mycologist, was on privilege leave for one month and 14 days from the 22nd August, 1921.

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MR. H. C. SAMPSON, B.Sc., has been appointed, on return from leave, to act as Director of Agriculture, Madras.

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MR. F. WARE, M.R.C.V.S., on return from leave, is reposted as Superintendent, Civil Veterinary Department, Madras.

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MR. B. S. PATEL, who has been appointed Deputy Director of Agriculture in the Indian Agricultural Service, has been posted to do duty as Associated Professor of Animal Husbandry and Dairying at the Agricultural College, Poona.

***

MR. GANDA SINGH CHEEMA has been appointed Horticulturist to the Government of Bombay.

MR. M. H. SOWERBY, M.R.C.V.S., Assistant Principal, Bombay Veterinary College, has been granted an extension of furlough for two months.

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MR. K. McLEAN, B.Sc., Offg. Fibre Expert, Bengal, has been allowed combined leave for one year with effect from the 18th October, 1921.

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MR. A. D. McGREGOR, M.R.C.V.S., whose services have been placed at the disposal of the Government of Bengal, has been appointed Superintendent, Civil Veterinary Department, Bengal.

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MR. P. J. KERR, M.R.C.V.S., has been appointed Second Imperial Officer, Bengal Veterinary College.

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MR. C. A. H. TOWNSEND, I.C.S., Director of Agriculture, Punjab, has been nominated a Member of the Legislative Assembly. Mr. Townsend has resigned his seat on the Punjab Legislative Council.

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ON return from leave, Lieut.-Colonel G. K. WALKER, C.I.E., O.B.E., has resumed charge of his duties of Principal, Punjab Veterinary College, Lahore.

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MR. C. J. N. CAMERON, M.R.C.V.S., Third Superintendent, Civil Veterinary Department, Burma, has been granted an extension of furlough for four months.

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DR. R. J. D. GRAHAM, Economic Botanist to Government, Central Provinces, has been granted combined leave for 20 months from 20th October, 1920.

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MR. R. H. HILL, Assistant Director of Agriculture, Jubbulpore, has been transferred to Chhindwara.

Mr. J. C. McDougall, Assistant Director of Agriculture, Nagpur, has been transferred to Raipur.

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Mr. S. K. Mitra, Economic Botanist to the Government of Assam, is appointed to be an additional corresponding member of the Assam Advisory Committee for Indian Students proceeding to England.

Reviews

Handbook of Spinning Tests for Cotton Growers.—By W. LAWRENCE BALLS, M.A., Sc.D. Published by Messrs. Macmillan & Co. for the Fine Cotton Spinners' and Doublers' Association, Research Department.

IN his book "The Development and Properties of Raw Cotton," Dr. Balls ends with a plea for the scientific study of cotton as a raw material for spinning. He shows there that even the most expert grader or broker may be entirely mistaken as to the spinning value of a new or unfamiliar cotton, and that such terms as length of staple, strength and fineness are not the simple physical characters which these terms suggest. In his present book written after several years' close application to the study of the "spinning characters" of cotton, he enters an even stronger plea for further study of the cotton fibre in relation to spinning, and we cannot do better than quote his own words.

"The fact that the Cotton Industry, when properly so called, includes the grower as well as the spinner, and the further fact that neither of these halves can work efficiently in a water-tight compartment of knowledge, is best illustrated by considering the case of a cotton-breeder who has been instructed to produce a new cotton."

"The advances in method and knowledge made during the past decade have reduced the operation of cotton-breeding to a comparatively straightforward process in so far as the isolation and purification of strains from impure commercial varieties is concerned. So long as the breeder is dealing with characteristics which influence the agriculture and yield of the crop, he is able to work on well-marked lines to definite objectives. But since cotton is grown

solely in order to be spun, it is most deplorable that the foresight, time, concentration and labour expended on the breeding of any single cotton should be devoid of any purpose or meaning so far as the spinner, who uses the cotton, is concerned.

"It is the fault of the spinner that this absurd situation exists. The technical knowledge of spinning is far less advanced than that of agriculture in general and of cotton growing especially. All that the spinner can prescribe to the cotton-breeder who is preparing a course of experiments is a vague recommendation to provide 'fineness' (which is undefined), 'length' (which is uncertain) and 'strength' (which has three different meanings).

"Seeing that the cotton-breeder must necessarily start work at least three years, and commonly five years, before he can produce even a small sample of cotton for testing purposes, the prospect of utilizing the scientific knowledge of the cotton-breeder deliberately to assist the cotton-spinner is, on these lines, very remote.

"For the moment, therefore, we resort to an empirical test, by allowing the cotton-breeder to produce whatever he can, confining his direct purpose to agricultural merits. Then when some two pounds of lint are available we subject it to the test of passage through a type of spinning machinery judged to be suitable, and measure the strength of the yarn it makes, as well as the amount of waste removed. In most respects this test is eminently sound; cotton is grown to be spun, and if it will not make good yarn it is not good cotton. But neither side is much the wiser after such a test. The data on both sides are not analysed, and without such analysis there can be no generalization, so that a new spinning test has to be made for every new sample although such a test is an expensive process, requiring skilled supervision at all stages.

"If it were possible to supplement the data concerning pedigree and environment which the grower possesses, and the further data about spinning and yarn which the spinner can provide, by detailed physical, chemical, and biological study of the hairs themselves, it might be possible before long to dispense with spinning tests except for final corroboration. All the spinning properties of a cotton sample are the expression of measurable properties of the cotton

hairs therein, mainly physical, and probably capable of being condensed to less than a dozen numerical constants. Once these are determined and correlated on the one hand with spinning, and on the other with plant growth, the causes involved in spinning quality will be analysed out, and the breeder will be able to work to a definite objective in respect to quality as well as to yield. He will endeavour to procure cottons having such values for these measurable properties of the hairs as the spinner—knowing then what he wants—will have demanded.

"Meanwhile, until this aim has been achieved, the extending use of the spinning test is a definite advance on the two older methods which it is displacing. The first of these was simply to propagate the new cotton into sufficient bulk to become a saleable product, and then to leave it to the decision of the market; this is the direct test of economic value, as distinct from the intrinsic value shown in a spinning test (which it in many ways resembles as being a direct determination of practical utility), but it took scores of bales where the latter takes pounds, and was therefore slow and expensive. The other method was to submit small samples of the new cotton to the handling and judgment of an expert grader, and this is a test purely of personal opinion.

"Since the spinning test came into sympathetic use, we have had so many cases of discrepancy between the opinion expressed by the graders and the actual result given by the cotton in the mill under repeated testing, that the grader no longer occupies a commanding position in settling the intrinsic value of a new kind of cotton. Where a familiar commercial variety is concerned, the grader's opinion still carries great weight, but with unfamiliar kinds, newly produced by the cotton-breeder, or grown under entirely novel conditions, the grader's opinion is simply interesting. This applies to Alexandria, to Liverpool, and to the spinners themselves in their preliminary handling. One case is on record where a sample graded as being almost hopeless came out at the head of a list of seven in the actual spinning. It is clear that in the past not only have many new cottons been brought into cultivation and failed to justify good opinions, but also we may fairly deduce a

conclusion that many more cottons which were intrinsically good have been condemned by the graders prematurely."

A clear account is given of the *processes*, as distinct from the machines, involved in modern cotton spinning, leading up to a detailed description of a routine for experimental spinning in Mr. McConnell's mill which enabled an accurate result to be obtained *in a commercial mill* from a two-pound sample as compared to the 100-pound sample previously considered necessary. In the chapter on the "Defects of the Spinning Test" Dr. Balls shows that the probable error of a spinning test can be reduced to 1·5 per cent. This is far less than the probable error of field experiments as usually carried out and, on the basis of the results obtained by Dr. Harland and Dr. Balls with checker-board plots, means that ten separate quarter-acre plots on the checker-board system would be required to secure the same degree of accuracy. The author points out that the mill spinning test though accurate is extremely laborious and expensive, if properly conducted, and draws attention to the extreme importance of adequate field experiments before spinning tests are called for.

A thoughtful chapter on the interpretation of the results of spinning trials follows which clearly brings out the fact that the spinning test is essentially a stage in cotton research and that it does not mean that a new cotton will at once command its real value in the market.

Under "Fundamental Data" the various constants which are capable of measurement are dealt with, and suggestions made for further research. [B. C. B.]

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The Book of the Mango.—By W. BURNS, D.Sc., and S. H. PRAYAG, M.AG. (Bulletin 103, Department of Agriculture, Bombay, 1920.)

ONE of the difficulties in taking up agricultural investigations in India is to ascertain what has been done in the past and where the various results obtained by previous workers are to be found. One method of overcoming this disadvantage is for the investigators

themselves to prepare readable accounts of the present position in the more important Indian crops. The process involves great labour, considerable self-denial and a good deal of research into forgotten records. Nevertheless, the results are of great value and are an indispensable preliminary to progress. Such a presentation has been made in the case of the mango by Dr. Burns and Mr. Prayag. In addition to a consideration of the records of previous workers, the authors have incorporated the results of their own investigations carried out at Poona and other places in the Bombay Presidency since 1908. While the bulletin is exhaustive and the whole subject has been covered, particular attention has been paid to the various methods of propagation. The chapters on soils and on the flowering of the mango are also of more than local interest. One subject of considerable importance to mango growers in the plains is, however, only mentioned, namely, the belief that damp weather at the time of flowering prevents the setting of fruit. From a casual examination of the flowers one would expect this result but no one seems to have studied this matter in sufficient detail for a period of years. Possibly the publication of this bulletin will be the means of suggesting this and a number of other interesting problems for investigation. While the results deal particularly with black soil conditions, this paper is of general interest and should be read by all interested in the development of fruit growing in India. [A. H.]

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Sanitary Entomology.—Edited by W. DWIGHT PIERCE. Pp. xxvi+518, 88 figs., 28 tabs., the Gorham Press, Boston; 1921. Price $10 nett.

THIS book originated in 1918 as a series of lectures delivered to a class of American entomologists formed to study recent developments in the entomology of disease, hygiene and sanitation, for the purpose of equipping themselves for any special service which they might be called upon to render during the war. These lectures have now been revised and are issued in book form.

The chapters on different subjects are written by various authors and deal with entomological problems primarily from the

municipal, industrial and household standpoints. Although written especially in connection with conditions in America, this book contains a valuable *résumé* of information on the various subjects included under its title, and should be in the hands of all in India interested in such matters as the control of flies, mosquitoes, lice, cockroaches, bedbugs and other disease-carrying Arthropods. [T. B. F.]

Correspondence

AGRICULTURAL MACHINERY TRADE IN INDIA.

To the Editor,

The Agricultural Journal of India.

Sir,

We have the honour to draw your attention to paragraph second on page 26 of "The Scientific Reports of the Agricultural Research Institute, Pusa, for 1919-20." The paragraph in question reads as follows :—

"The agricultural machinery trade in India is at present in an unsatisfactory state. Makers have no direct representatives in India but are represented by agents in the large towns. There are no stocks in the country and spare parts are increasingly difficult to get, and for these exorbitant prices are sometimes charged. For example, a bill was presented for Rs. 1,200 for spares for a couple of reaping machines. Makers will undoubtedly have to contemplate the appointment of their own agents and the opening of depôts in up-country districts."

Following, as it does, a return of the working of the set of "Fowler" cable tackle which has been in use at the Institute since 1913, we fear that the remarks contained in the paragraph in question may be unjustly applied by the reader to our own firm.

This being the case, we have the honour to request that you will be good enough to correct any false impression which may have been created by informing readers, through the medium of "The Agricultural Journal of India," that we have been established in India for nearly fourteen years as a direct branch of Messrs. John Fowler & Co. (Leeds), Ltd., Leeds, England. The question of

technical service and the proper maintenance of an adequate stock of spare parts have always received our special consideration. The result is that our organization ensures that users of our machinery have at all times the benefit of expert advice as well as the satisfaction of knowing that they can obtain duplicate parts, when required, at the shortest possible notice, from our Indian stock.

12th September, 1921.

Yours faithfully,

For John Fowler & Co. (Leeds), Ltd.,

H. S. Sayer,

General Manager for India.

NEW BOOKS

ON AGRICULTURE AND ALLIED SUBJECTS

1. British Insect Life : A Popular Introduction to Entomology, by E. Step. Pp. 264+32 plates. (London: T. Werner Laurie, Ltd.) Price, 10*s*. 6*d*. net.
2. Chemical Disinfection and Sterilization, by S. Rideal and E. K. Rideal. Pp. vii+313. (London : E. Arnold & Co.) Price, 21*s*. net.
3. Date and Date Cultivation of the 'Iraq,' by V. H. W. Dowson. (Cambridge : W. Heffer and Sons, Ltd.)
4. The Book of Nature Stories, by H. W. Seers. Pp. 256. (London and Sydney : G. G. Harrap & Co., Ltd.) Price, 5*s*. net.
5. The Breeding and Feeding of Farm Stock, by James Wilson. Pp. 152. (London : Methuen & Co.) Price, 6*s*. net.

The following publications have been issued by the Imperial Department of Agriculture in India since our last issue :—

Memoirs.

1. Investigations on Indian Opium. No. 1. Non-environmental Factors influencing the Alkaloidal Content and Yield of Latex from the Opium Poppy (*Papaver somniferum*), by Harold E. Annett, D.Sc. (Lond.), F.I.C., M.S.E.A.C., Hari Das Sen, M.Sc., and Har Dayal Singh, B.Sc. (Chemical Series, Vol. VI, No. 1.) Price, R. 1-8 or 2*s*.
2. Investigations on Indian Opium, No. 2. The Effect of Non-environmental Factors on the Alkaloidal Content and Yield of Latex from the Opium Poppy (*Papaver somniferum*) and the bearing of the work on the functions of Alkaloids in Plant Life, by Harold E. Annett, D.Sc. (Lond.), F.I.C., M.S.E.A.C. (Chemical Series, Vol. VI, No. 2.) Price, Rs. 2 or 2*s*. 9*d*.

3. Life-histories of Indian Insects. Diptera: *Sphryracephala hearseiana*, Westw., by S. K. Sen, B.Sc. (Entomological Series, Vol. VII, No. 6.) Price, As. 12 or 1*s*.

Bulletins.

4. Annotated List of Indian Crop-Pests, by T. Bainbrigge Fletcher, R.N., F.L.S., F.E.S., F.Z.S. (Bulletin No. 100.) Price, R. 1-8.
5. Some Insects recently noted as Injurious in South India, by T. V. Ramakrishna Ayyar, B.A., F.E.S., F.Z.S. (Bulletin No. 101.) Price, As. 8.
6. Borers in Sugarcane, Rice, etc., by T. Bainbrigge Fletcher, R.N., F.L.S., F.E.S., F.Z.S., and C. C. Ghosh, B.A. (Bulletin No. 102.) Price, R. 1.
7. Some Indian Economic Aleyrodidæ, by C. S. Misra, B.A. (Bulletin No. 103.) Price, As. 8.
8. The Rice Leaf-hoppers, by C. S. Misra, B.A. (Bulletin No. 104.) Price, As. 6.
9. The Pink Bollworm in Egypt, by Lewis H. Gough, Ph.D., F.E.S. (Bulletin No. 106.) Price, R. 1.
10. Some Pests of Cotton in North Bihar, by C. S. Misra, B.A. (Bulletin No. 108.) Price, As. 6.
11. *Tukra* Disease of Mulberry, by C. S. Misra, B.A. (Bulletin No. 109.) Price, As. 4.
12. Stored Grain Pests, by T. Bainbrigge Fletcher, R.N., F.L.S., F.E.S., F.Z.S., and C. C. Ghosh, B.A. (Bulletin No. 111.) Price, As. 14.
13. Notes on Rearing Insects in Hot Climates, by T. Bainbrigge Fletcher, R.N., F.L.S., F.E.S., F.Z.S., and C. C. Ghosh, B.A. (Bulletin No. 112.) Price, As. 7.
14. Hints on Collecting and Preserving Insects, by T. Bainbrigge Fletcher, R.N., F.L.S., F.E.S., F.Z.S. (Bulletin No. 113.) Price, As. 10.
15. Note on Plant Imports into India, by T. Bainbrigge Fletcher, R.N., F.L.S., F.E.S., F.Z.S. (Bulletin No. 114.) Price, As. 7.

16. Experiments with Castor Seed Conducted at Sabour, by C. Somers Taylor, B.A. (Bulletin No. 117.) Price, As. 3.
17. The Agricultural Development of Baluchistan, by Albert Howard, C.I.E., M.A., and Gabrielle L. C. Howard, M.A. (Bulletin No. 119.) Price, As. 6.
18. The Serum Simultaneous Method of Inoculation against Rinderpest, by W. A. Pool, M.R.C.V.S. (Bulletin No. 120.) Price, As. 2.
19. Notes on Contagious Abortion in Pony and Donkey Mares, by R. Branford, M.R.C.V.S., and T. M. Doyle, F.R.C.V.S. (Bulletin No. 121.) Price, As. 5.
20. Pusa 12 and Pusa 4 in the Central Circle of the United Provinces, by B. C. Burt, M.B.E., B.Sc., F.C.S., Albert Howard, C.I.E., M.A., and Gabrielle L. C. Howard, M.A. (Bulletin No. 122.) Price, As. 11.
21. Safflower Oil, by Albert Howard, C.I.E., M.A., and J. Stewart Remington. (Bulletin No. 124.) Price, As. 4.

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